JOURNAL
OF THE
AMERICAN WATER WORKS ASSOCIATION

Vol. 35 OCTOBER 1943 No. 10

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Vol. 35 October 1943 No. 10

Water Big Factor in Sicily

By Ernie Pyle

SICILY was known to be short of water in summertime, so our invasion forces brought enough water with them to last five days. In the case of the 45th Division this amounted to 155,000 gallons. It was brought both in tanks and individual five-gallon cans. There were three ships with tanks of 10,000 gallons each. And then on the transports there were 125,000 gallons, all in five-gallon cans. That meant that this one division brought with it from Africa 25,000 cans of water. Just think of it—25,000 cans! And other divisions did the same.

Actually, we didn't have as much trouble finding water as we'd expected and we needn't have brought so much with us, but you never know. Napoleon said an army marches on its stomach, but I think you could almost say an army marches on its water. Without water you're sunk. (As an old punster, how in the hell can you sink without water? Well, I said it; you figure it out.)

50,000 Gallons a Day

Throughout the Sicilian campaign, the 45th Division used about 50,000 gallons of water a day, or two gallons a man. Just as a comparison, the daily water consumption in Las Vegas, N.M., a city [metropolitan area] of 12,000, is a million gallons a day or almost 100 gallons a person.

Although the difference seems fantastic, still our troops used more than absolutely necessary, for an army can exist and fight on one gallon a day per man.

It falls to the engineers to provide water for the army. Engineer officers scout the country right behind the retiring enemy, looking for water places.

A newspaper article first published in the *New York World-Telegram* on September 3, 1943. One of the day to day series by Ernie Pyle, Roving Reporter for the Scripps-Howard Newspapers, by wireless from "Somewhere in Sicily." Republished by permission of John H. Sorells, Executive Editor, Scripps-Howard Newspapers. This article will be recognized as one of a series from the war correspondent, who, from day to day, is bringing to the American people the most human, as well as the most informative, accounts of the nation's military forces in action. This article merits a permanent place in the published records of the American Water Works Association—first, because it is a bit of good reporting; second, because it is a worth-while record of water supply in the field; and third, because this Association's own members, both military and civilian, have had much to do with the development of the equipment described.

They always keep three water points set up for each division—one for each three regiments and usually a couple of extra ones. When a water point is found, the engineers wheel in their portable purifying unit. This consists of a motorized pump, a sand filter, chlorinating machine and a collapsible 3000-gallon canvas tank which stands about shoulder high when put up.

Filled From Tank

Purified water is pumped into this canvas tank. Then, all day and all night, vehicles of the regiment from miles around line up and fill their cans, tanks and motors by a hose out of this tank.

Painted signs saying "Water Point," with an arrow pointing the direction, are staked along the roads for miles around.

The sources of our water in Sicily were mainly wells, mountain springs, little streams, shell craters and irrigation ditches. The engineers of the 45th Division found one shell crater that contained a broken town water main, and the seepage into this crater provided water for days. They also discovered some of Sicily's dry riverbeds had underground streams flowing beneath and by drilling down a few feet they could pump all they needed.

Irrigation Ditch Helped

Another time they put pumps into a tiny irrigation ditch only four inches deep and a foot wide. You wouldn't think it would furnish enough water for a mule, yet it kept flowing and carried them safely through.

In their municipal water systems the Sicilians use everything from modern 20-inch cast-iron pipe down to primitive earthen aqueducts still there from the Roman days.

Our engineers made it a practice not to tap the local water supplies. We made a good many friends that way, for the Sicilians said the Germans used no such delicacy. In fact, we leaned over the other way and furnished water to scores of thousands of Sicilians whose supply had been shattered by bombing.

Sediment Removed

It doesn't make much difference what shape the water is in when you find it for it is pumped through the filter machine which takes out the sediment. Then purifying substances are shot in as it passes through the pumps. The chlorine we inject comes in powder form in one-gallon cans. We usually use one part of chlorine to a million parts of water.

The 45th's engineers brought with them enough chlorine to last six months. In addition to chlorine, alum and soda ash are injected in the water. After you've drunk this water for as long as we have you don't notice the odd taste.

The 45th brought six complete water purifying units with it and also brought a unit for distilling drinking water out of sea water but this never had to be used.

Canteens Captured

When he marches or goes into battle an infantryman carries two canteens instead of one, but here in the hot summer it isn't unusual at all to see a soldier carrying six canteens tied to the end of a leather strap like a bunch of grapes—half his canteens being captured Italian ones covered with gray felt for keeping the water cool.

And, I might add, out of the side of my mouth, if you got real nosy you might discover that a couple of those canteens, instead of holding our beautiful pure water, were bearing a strange red fluid known colloquially as *"vino,"* to be used, no doubt, for rubbing on flea bites.

The Finest Drink

A GLASS of fresh water, according to a recently returned Boston army nurse who has been in Algiers, is the greatest luxury. Certainly soldiers who have been slogging along in the dust of Sicilian roads, with nothing but chlorinated water or the lava-flavored wine of that island to wet their whistles, would agree with the nurse. The vote would be unanimous among the soldiers, sailors and marines who have fought their way into the jungles after the wily Jap.

Connoisseurs of water, who exist in greater numbers than connoisseurs of wine, differ on the best vintage of Mother Nature's purest gift to man. Some say that water from a mountain spring is best. Others prefer it from a well, tasty, to slight degree, with the flavor of moss and stone. State of Maine folk often champion water from a lake, like Portland's famous Sebago. Others, completely citified, insist that water is best when taken from a river and refined, by devious ways of science, into something that will pour easily through a faucet.

Those who have tramped through "the bush," whether our own big woods or the dry forests of Central America, know only too well that nothing but water truly quenches thirst. Champagne is all very well for weddings, and the tinkle of a properly made julep sounds delightful on a hot day. But what goes down quite so easily as good water, anywhere in the world? Other commodities—cold creams, lipsticks, silk stockings, wines and caviar—are the luxuries which we can do without. Water is the great essential to a man's well being.

A young sergeant just back from Asia sums it all up in his own way, in writing to a buddy still at the front. "You'd find a lot of changes coming back to America now," he writes, "but probably more important are the unchangeable little things you never thought about until you got over there—like the water you can drink from the faucets. . . ."

An editorial from the *Boston Herald* of August 24, 1943.

Good Practice in Laying Concrete Pipe

By Louis R. Howson

IN the past year or two, there has been a growing appreciation of concrete pipe, particularly for use in the larger sizes. Among its advantages for water works use are: (1) a high carrying coefficient, usually 140–150 or more by the Williams-Hazen formula; (2) its ability to maintain the initial carrying capacity unimpaired; (3) safety resulting from a stretch, rather than a rupture, type of failure; and (4) saving in critical materials, especially important during the war emergency.

Although concrete pressure pipe has been successfully and extensively used in this country for more than thirty years, and abroad for almost fifty years, a great many pipe-laying contractors have had no experience with it, due to the fact that, in this country, most of it has been laid by those who manufacture it. During the present emergency, however, the demand for concrete pipe has been so great that much of it could not be laid by the manufacturers. Thus, new problems have been presented.

In any installation of concrete pressure pipe, three considerations are of primary importance:

1. A manufacturer with a background of successful performance in this specialized type of construction should be selected.

2. If at all possible, a single contract should be made for the complete job, including both the manufacture and the laying of the pipe.

3. If the laying of the pipe must be contracted for separately, the pipe manufacturer should be required to furnish an experienced superintendent for the laying contract and the pipe-laying contractor should be required to perform his work so as to have the approval of this manufacturer's representative. It is also believed desirable to require the pipe-laying contractor and the manufacturer to share the responsibility for watertightness.

Concrete pressure pipe is ordinarily used for relatively large diameters, i.e., from 30 in. to 12 ft. It has been used where the diameter of the pipe exceeded the section length. The ratio of diameter to pipe length usually varies from 25 to 50 per cent, which indicates one of the reasons for some of the special considerations to be observed in the laying procedure.

Many of the requirements for laying concrete pipe are identical with those for laying cast-iron pipe, which have been so ably presented in the A.W.W.A. "Standard Specifications for Laying Cast-Iron Pipe—7D.1-

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A paper presented on June 16, 1943, at the Cleveland Conference by Louis R. Howson, Cons. Engr., Alvord, Burdick & Howson, Engrs., Chicago.

1938," but no specifications have as yet been developed to cover the special features of the procedure. In April 1943, the A.W.W.A. issued its "Tentative Emergency Specifications for Reinforced Concrete Pressure Pipe—7B-T" (Jour. A.W.W.A., **35**: 499 (1943).) but these cover only the manufacture of the pipe. In this paper the author proposes to supplement the information of these two sets of specifications by describing the special procedures that must be applied in the laying of concrete pressure pipe.

Co-ordination of Manufacture and Laying

The manufacture and laying of concrete pressure water pipe are specialized operations. To secure the best results, the two operations must be well co-ordinated. Success with reinforced concrete pipelines depends quite largely upon the design and execution of the joint, so that there is a decided advantage in concentrating the responsibility for leakage in one contractor rather than in two. This was recognized in the A.W.W.A. reinforced concrete pipe specifications by the following statement in the foreword:

> Specifications for laying the pipe should include provisions that the purchaser may stipulate that the manufacturer of concrete pipe be required to furnish a competent superintendent on the job when the pipe is laid and that such superintendent shall ascertain that all joints are made in accordance with the manufacturer's recommended practice. Pipe-laying specifications should also provide that the purchaser may stipulate that pipe laid under the manufacturer's supervision shall, after hydrostatic test, exhibit no greater rate of leakage than that stipulated in Sec. 15 of the A.W.W.A. "Specifications for Laying Cast-Iron Pipe—7D.1-1938" for pipe of equal diameter.

The remainder of this discussion, then, will be predicated upon the assumption that the pipe will conform to these A.W.W.A. specifications.

Delivery

Concrete pipe must at all times be handled with care to avoid damage, especially through chipping of collars or bells. Concrete pipe is heavy material; each length usually weighs several tons. The heaviest sections on such projects as the Colorado Aqueduct, the Boston Aqueduct and the Toledo intake weighed over 40 tons each. In loading and unloading, the pipe section should be lifted by hoist or derrick or rolled on skidways in such manner as to avoid shock. They should never be dropped. The difference between careful handling and ordinary rough handling may be illustrated by two recent jobs. On one of these only one length of 58-in. diameter pipe, in a total of 29,000 ft., was broken after it left the yard; on the other contract, 50 lengths in a total of 60,000 ft. were broken. The higher breakage was experienced on a job where the laying contractor had not previously installed concrete pressure pipe, although he had laid much concrete sewer pipe.

The laying contractor's responsibility for materials should begin at the point of delivery to him. The laying contractor should examine all materials furnished at the time and place of delivery; it should be his responsibility, then and there, to reject all defective material. Any defective material not so rejected, and discovered prior to the final acceptance of the work, is a divided responsibility, for the repair of which the pipe manufacturer should furnish such additional materials and supplies as may be necessary and the laying contractor, the labor for the removal of the defective material and

the installation of the new material. If materials are damaged after being received by the laying contractor, that, of course, is the laying contractor's complete responsibility.

As the pipe is distributed along the trench, it is good practice to support it on skids. This assists in keeping the interior clean and prevents breakage. Otherwise, the heavy pipe may sink into soft soil and be broken when lifted by the crane. On a recent job, in which construction was carried on during a period of alternate freezing and thawing temperatures, considerable breakage occurred as a result of trying to lift pipe that had frozen to its bed along the side of the trench.

Trenching

The back hoe or hoe digger is most commonly used in trenching for concrete pipe. It usually serves both as a trenching machine and as a crane for lowering pipe into the trench.

The back hoe usually excavates immediately in advance of pipe laying and not more than a pipe length at a time. This helps prevent caving and widening of trench, which is important in limiting the loading on pipe of large diameter.

A ladder type trenching machine is sometimes used where trenches will stand vertically but this type of equipment requires a power tractor crane for lowering the pipe into the ditch. In addition to requiring the second equipment unit, the digging speed of the ladder type excavator is so much greater than the speed at which it is practicable to handle, lay, bed and join the concrete pipe that an excavator of this type has too much idle time. Ditching for the construction of a concrete main is different from that required for cross-country gas- or oil-line construction.

In laying large concrete pipe, it is not advisable to attempt to shape the bottom of the trench to conform to the cylindrical shape of the pipe exterior, since it is practically impossible to secure an even bedding for the pipe in this way. Best practice consists of excavating a substantially flat bottom trench. As the excavation approaches grade, the final grading is done by hand and the dirt thrown forward and removed by the hoe. With concrete pipe, proper bedding depends upon a uniform support along the bottom diameter of the pipe, supplemented by proper backfilling. The backfill should be carried up simultaneously on both sides of the pipe in 6-in. layers, each layer being carefully compacted by tamping. All backfill *must* be tamped to an elevation at least as high as the center of the pipe and *preferably* to the three-quarters point. Extreme care in compacting the backfill under and around the pipe is the best insurance against unequal settlement and the bending moments induced thereby.

Where trench excavation is in rock, the excavation must be carried below grade a sufficient distance to provide a cushion layer of firm earth in the bottom of the trench that will be thick enough to prevent the pipe from settling down to a bearing upon any point of rock. Practice in this respect parallels that for cast-iron pipe.

When the excavation is finished to grade, a length of pipe is picked up in a sling attached to the end of the boom of the back hoe or the power crane and lowered into the trench. The spigot end is inserted into the bell or collar and pushed home. Due to the great weight of the pipe length, the

sling support is retained until the pipe is adjusted to its final line and grade.

Underdrainage and Cradles

Since concrete pipe is usually of large diameter and, therefore, heavy, any settlement is undesirable with most types of joints. Where soft foundations are encountered, satisfactory foundations must be provided. This is usually accomplished either by: (1) excavating a foot or more below grade and stabilizing the foundation with gravel or crushed stone surrounding a drain leading to a sump for use in dewatering during construction; or (2) using piling and timber cradles in extreme cases.

Surface as well as underdrainage must have attention. Natural drainage lines crossing a trench line must be carried by culverts or equivalent construction, so that surface drainage cannot travel along the trench, erode the backfill or cause unequal settlement.

Joints

Joints on pressure type concrete pipe are of various designs, including concrete collars, hub and spigot and variations of tapered joints. The joint materials most commonly used are: (1) lead and jute, in the gasket type joint developed and used so successfully by the Lock Joint Pipe Co.; (2) rubber in the rings more recently used by several pressure pipe manufacturers; and (3) cement, either poured or calked.

When the material is rubber, the joint is usually of the ring gasket type stretched over the spigot end and put in place as the pipe is laid, thus completing the watertight seal. The space in the bell at the outside of the pipe is then filled with grout or mortar and the trench backfilled. The filling of the interior of the joint should be deferred until the backfill is placed, at least to the center of the pipe, so as to avoid possible cracking due to settlement.

If the sealing element is of a material less resilient than rubber, it is of advantage to arrange the construction procedure so that the pipe can receive its load of backfill with time for settlement of the pipe and consolidation of the backfill before the final operation of making the joint watertight with the non-resilient sealing material.

Where the fiber-filled lead gasket joint is used, the ring is placed in the bell as the next spigot is inserted. This gasket is then given a preliminary light calking. The exterior of the joint is then filled with poured grout, the backfill carefully compacted, the lead gasket firmly calked and the interior of the joint filled and smoothed with mortar. In this joint, the lead gasket is calked between steel rings. The mortar and grout are not relied upon for watertightness.

Calked mortar joints are frequently used with collars. The mortar should be either neat cement or $1\frac{1}{2}$ parts cement to 1 part plaster, hand-mixed, with just sufficient water to enable it to adhere under pressure. Mortar should be calked in layers not exceeding $1\frac{1}{2}$ in. in thickness.

Poured joints should be made of cement grout consisting of 1 part cement to $1\frac{1}{2}$ parts sand, mixed to the consistency of thick cream. A rope runner held in place by the backfill is used. The joint should be flushed with water prior to being filled with the grout and the grout pour should be a continuous operation. The joint should

be either vibrated or rodded on both sides of the pipe with flexible wire to settle the grout; then deficiencies should be filled. The rope gasket must remain in place to protect the joint.

On all concrete pipe of 36-in. and greater diameter, it is customary to point up the inside of the joint with mortar. This is one of the factors contributing to the high coefficient of carrying capacity of concrete pipe.

Prior to the war, the rubber gaskets were made with a large proportion of crude rubber. As a result of the rubber shortage, experiments were conducted to ascertain the minimum amount that would give a gasket satisfactory resiliency. The maximum amount of rubber which gasket manufacturers are now permitted to put in rubber gaskets is limited by the WPB to about one-third by volume. This reduces the resilience of the wartime gaskets, but they appear to be satisfactory after installation.

The rubber gasket is commonly imbedded in a groove cast in the spigot of the pipe. As the bell or collar is forced over the spigot, this gasket is compressed, thus forming the watertight joint. In a recent installation on the Mill Creek, Ohio, FWA job, part of the 36-in. pipe was laid with a bell and spigot type joint, using a shoulder instead of an annular groove cast on the spigot. The rubber gasket was forced back against the shoulder as the pipe was laid; then the outside of the joint was calked with cement mortar.

Observation of various contracts would indicate that longer lengths are preferable. Practice varies from providing 8- to 16-ft. lengths at the present time. The tendency is toward using longer lengths with fewer joints.

Access Manholes

In view of the fact that the joints are pointed up from the inside, and to facilitate inspection and subsequent repair if necessary, access manholes should be provided at intervals of 1000 to 1200 ft. Their cost is fairly small and it is better to have the spacing too short than too long.

Backing

Because of the larger diameters and the magnitude of pressures resulting at bends, angles, tees and plugs, all such specials should be backed with properly designed concrete buttresses or holding-down weights. These should be adequate to prevent any movement in the trench after construction is completed.

A well designed, well constructed concrete pipeline can be built for almost any head or other operating condition. In most situations it is competitive with other materials in price for sizes of 30 in. in diameter and larger, has a very high coefficient of carrying capacity (which, with most waters, is well maintained over the years) and has a record of requiring little or no maintenance expense. The coefficient of carrying capacity by the Williams-Hazen formula is normally 140 or higher and the leakage per inch diameter per mile of main is frequently as low as 25 gpd.

A concrete pipeline that is not well designed and well laid and which develops settlement and leakage after construction is difficult to repair. Designing, manufacturing and laying concrete pipe are not jobs for an amateur, but, when all are well done, concrete pipe provides an excellent type of water works pipeline construction.

Experience With Wire-Wound Prestressed Concrete Pressure Pipe in Chicago

By W. W. DeBerard and W. B. Weldon

THE use of concrete water pipe in Chicago is a departure from general practice, as the entire distribution system of 3851 mi. is made up of cast-iron pipe and a few short sections of steel pipe installed because of special conditions. The introduction of concrete water pipe into this system has been one of the many innovations brought about by wartime shortages of materials.

During the summer of 1942, the federal government decided to locate a war production plant just inside the southwest limits of the city. One of the important considerations in this decision was the readiness of the city to furnish an adequate supply of water, estimated at 10 mgd., to assure which it would be necessary to lay 11,244 ft. of 36-in. feeder main. Since WPB regulations restricted the use of iron pipe, it was found that some substitute material would have to be used.

In Chicago, all pipe is laid by the regular municipal labor forces, only the material being furnished on contract. Thus, the specifications for the required amount of pipe were so drawn that all types of pipe could be bid on, but requiring the bidder to furnish detailed plans and specifications of his particular type. Additional provisions required that the pipe withstand an hydraulic yard test of 200 psi. without cracking or harmful seepage and that total leakage under a 150-psi. field test of the pipeline not exceed 150 gpd. per inch-mile. The contractor for the pipe was also required to furnish a representative to supervise the making of the joints, so that he would be responsible for their watertightness.

Bids were asked on a price-per-foot basis for 11,244 lin.ft. of 36-in. pipe and on a price-per-unit basis for special connection fittings listed. The price bid was to include all sleeves, gaskets or other appurtenances necessary to install the pipe and all fittings in the pipeline. It was also to provide for delivery on the street along the proposed pipeline. The branches of the fittings were required to be equipped so that a connection could be made with Class B cast-iron pipe and the 24-in. valves, to be set every half mile, were to be furnished by the city.

Bids were invited on three types of pipe: steel shell encased in concrete, reinforced concrete and asbestos-cement. The low bid on the steel shell encased type was $10.25 per ft. and that on the reinforced concrete type

A paper presented on June 16, 1943, at the Cleveland Conference, by W. W. DeBerard, City Engr., and W. B. Weldon, Asst. Engr., both of the Dept. of Public Works, Chicago.

$9.44 per ft. No bids were received on the asbestos-cement type.

The low bidder was the Material Service Corporation, bidding on "Lewistown Prestressed Concrete Pipe" and Class B cast-iron special fittings. This concrete pipe was a comparatively new type in the field of high-pressure water pipe, but the city had had some previous knowledge of it in 1941 in the laying of a 30-in. water line in a suburb. The city engineers had been close observers of the performance of this pipe, both during the laying and under tests, as a result of which they were favorably impressed with it.

A close study of the detailed drawings and specifications, together with correspondence with users of the pipe and visits to the manufacturing plant, convinced the city's engineering staff that the pipe was well designed and would furnish a satisfactory pipeline under the specifications. Accordingly, the contract was let on October 18, 1942, and manufacture was started November 30.

Spinning Operation

The pipe is molded in 12-ft. lengths, i.e., it makes up 12 ft. in the line. The inner shell of 3 in. of concrete is formed by the centrifugal process, two pipes being made at the same time. First step in the process is the assembling of two forms, each consisting of a steel shell with one longitudinal joint that is bolted shut (Fig. 1). Cast-steel rotating rings are then fitted on each end and the insides of the rings are formed to shape the ends of the pipe with a taper. The form is then coated with a rosin solution and the joints are taped to prevent leakage.

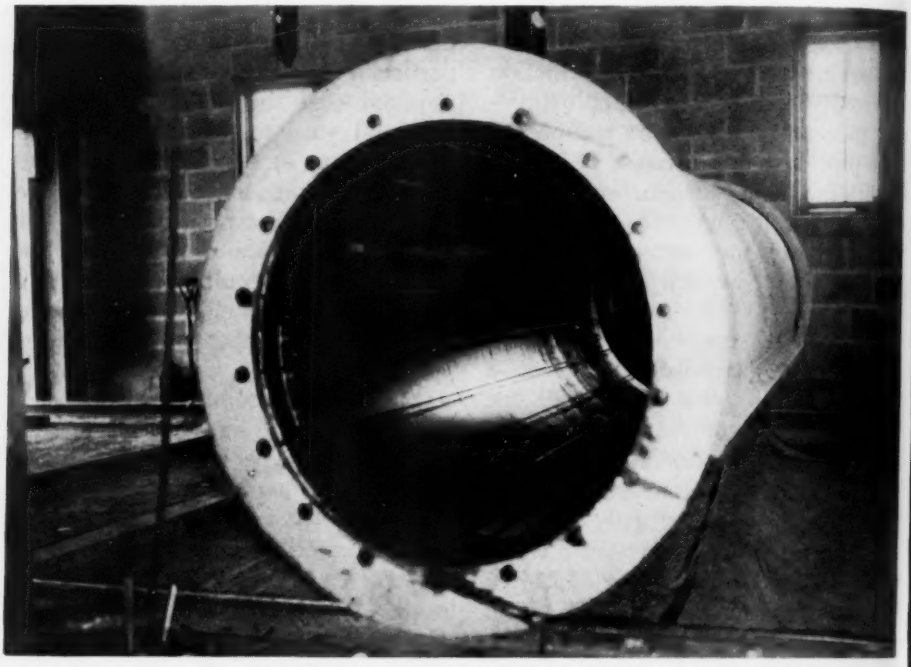

FIG. 1. Centrifugal Form for Concrete Pipe Section

Eighteen longitudinal rods of $\frac{5}{16}$-in. steel are inserted in the form 1 in. from its inside face and projecting through the end rings. Nuts on the threaded ends are pulled up by means of a strain wrench, so that each rod is under a stress of 30,000 psi. The forms are then placed on the rollers of the spinning machine.

Concrete is mixed in a batch mixer close by and is wheeled in concrete carts and dumped at each end of the forms on the concrete floor. The spinning is then started at 90 rpm. and one man at each end shovels into the form enough concrete to make up one-half the wall thickness (Fig. 2). After it is placed, the speed is increased to 250 rpm. and the form is spun for 10 min. This spinning compacts the concrete and drives out the water, which is carried on the inside surface until the spinning is stopped, at which time the water runs out the ends of the form (Fig. 3) and is broomed out until most of it is removed.

The floor is then broomed into a drain and another batch of concrete is dumped, after which the spinning at 90 rpm. is resumed and the balance of the wall thickness formed. Spinning is again stepped up to 250 rpm. for 12 min., during which each man slides a bar in and along the surface to true up the pipe and remove the water. Following this, the machine is stopped and the surface examined for projections or for any foreign materials. Finally, the spinning is resumed for another 5 min. (Fig. 4), during which time a thin coating of mortar is troweled into the interior surface. At this point, the concrete is so hard and dry that no foot impressions are made.

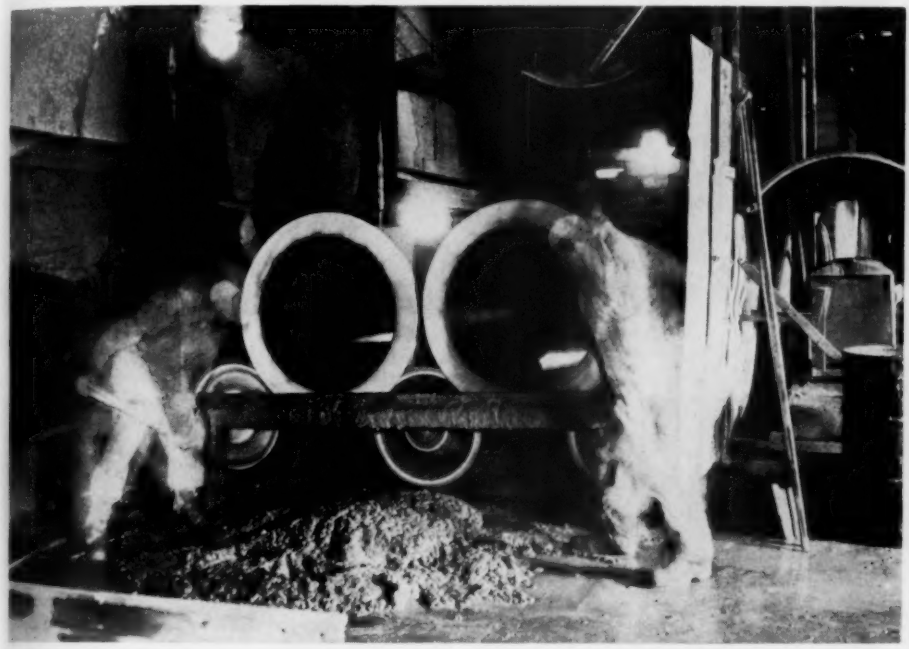

FIG. 2. Two Forms on Spinning Machine; showing placement of concrete in rotating forms

The purpose of spinning the wall in two operations is more certainly to

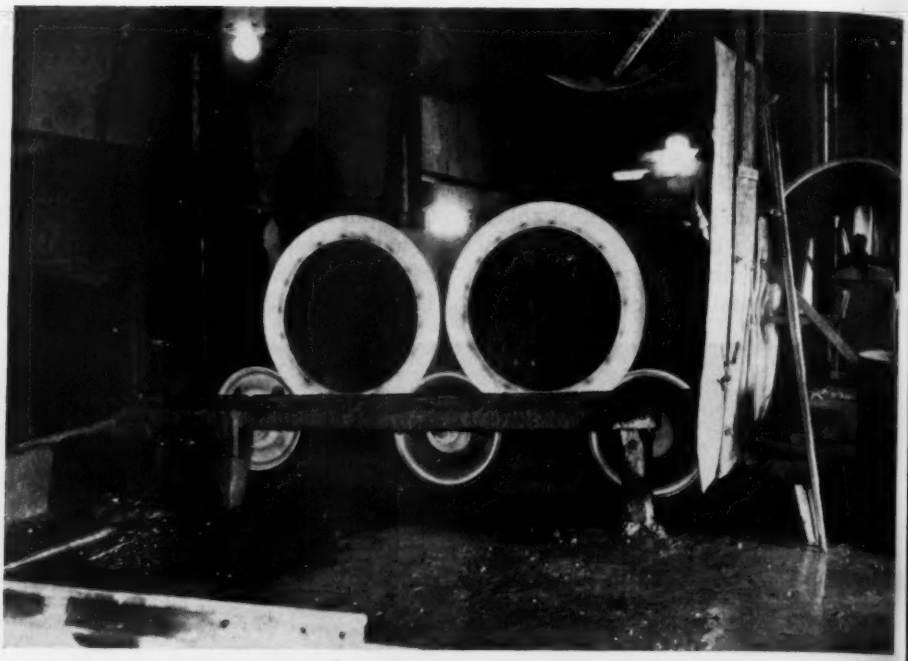

FIG. 3. Water Leaving Surface of Forms as Speed Is Reduced

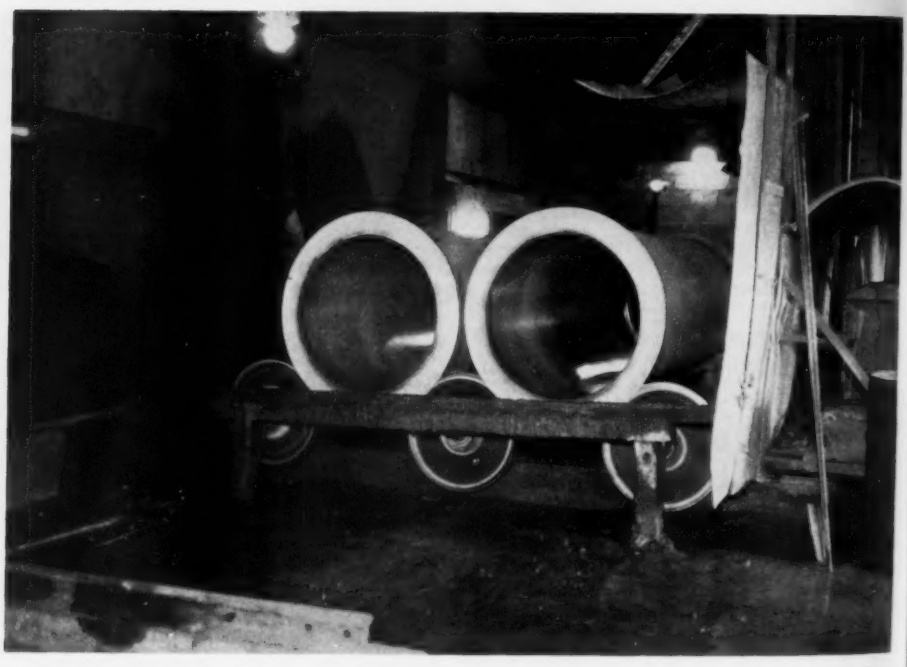

FIG. 4. Final Spin of Two 36-Inch Pipe Sections; showing smoothness of finished interior surface

remove the excess moisture and to prevent segregation of the materials in the concrete mix.

Curing and Removal of Forms

When the spinning process has been completed, the forms are lifted by chain hoists, moved laterally, set on rails and rolled into a steam room for 24 hr. of curing. Before the pipe has cooled, the forms are removed, leaving the pipe hanging on hooks on a chain hoist. In removing the forms, the nuts on the longitudinal rods are first unscrewed, then the end rings are removed. When the nuts are released, the 30,000-psi. tension in the rods is taken up by the bond of concrete, with a resulting compression of 90 psi. in the concrete. This represents the longitudinal prestressing in the concrete. The pipe is then carried laterally and placed on a pair of tracks over which it is rolled into another steam room and allowed to cure for at least two more days.

Wire Wrapping

After final curing, the pipe is ready for wire wrapping (Fig. 5). It is then placed in a wire-stressing machine, parallel to which an ingenious dead-weight wire feeding machine travels with the pipe under an automatic travel control (Fig. 6). The wire is made of oil-tempered spring steel and has an ultimate tensile strength of from 210,000 to 225,000 psi. The pipe made on this contract required a No. 6 wire, which, under the specified test requirement of 200 psi., was computed to be spaced on 0.51-in. centers as wound spirally. The pull on the wire, as wound, was 2600 lb., resulting in a compression stress of 1500 psi. in the concrete inner wall.

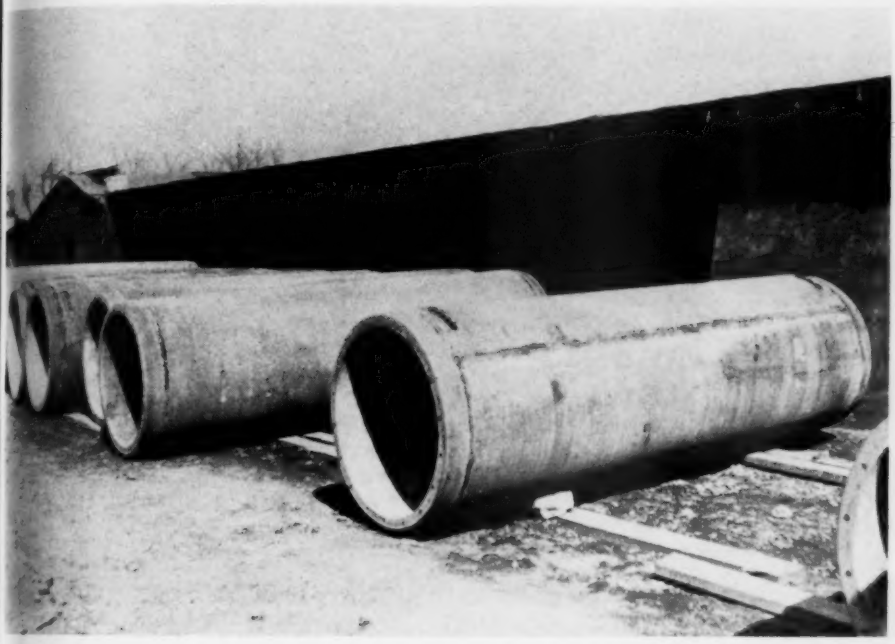

FIG. 5. Sections of Pipe Inner Walls Ready for Wire Wrapping

Hydraulic Testing

Following the wrapping, the pipe was subjected to hydraulic test (Fig. 7). The specifications provided that one pipe section from each day's output of the spinning machine be selected at random for testing under a 200-psi. pressure. In addition, the manufacturer chose to test every pipe under a pressure of 70 psi. Of a total of 939 completed, 92 pipe sections have been tested under 200-psi. pressure and not one has shown any evidence of leakage within the joints or through the body of the pipe. Most of the sections were only three days old when tested.

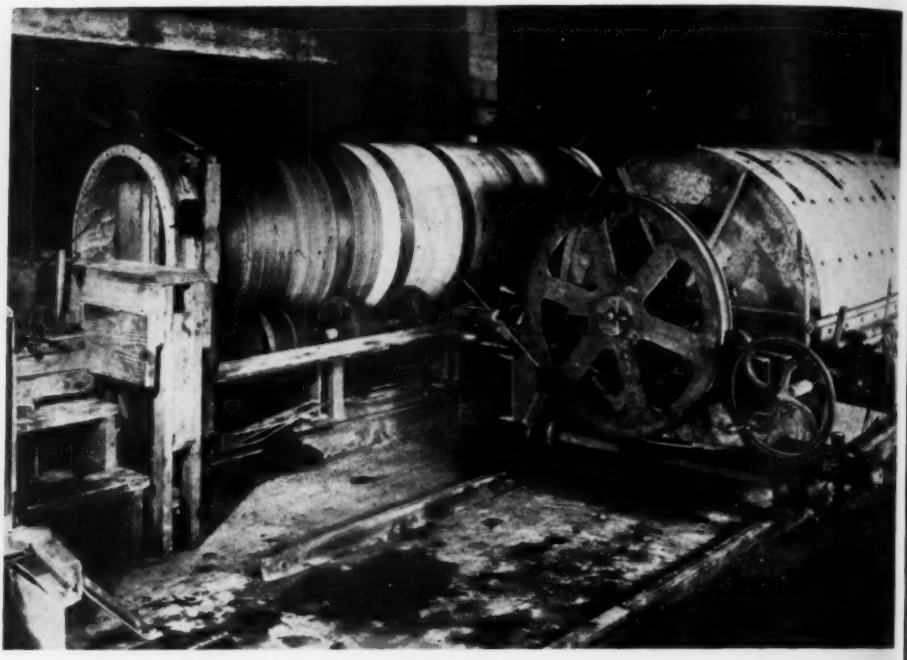

FIG. 6. Wire Wrapping Equipment; showing pipe section in rotating machine and dead-weight wire-feeding machine

Protective Coating

After the testing, the pipes are rolled into the yard on blocking and a steel sleeve, in which a gasket is inserted, is pulled on one of the pipe ends. A mesh reinforcement is set over the sleeve and extended 8 in. back over the pipe. The pipe sections are then lifted to a vertical position with a crane and set with the sleeve end down on a cast-iron base ring. An outside form is set down over the pipe and the 1-in. outside wall of concrete is poured (Fig. 8). Attached to the rib of the form is an electric vibrator which is operated as the concrete is deposited, releasing air pockets and water and producing a dense concrete wall. This wall is used merely to protect the steel wire against corrosion.

The rack of 40 pipes is then enclosed within sectional wooden walls and covers. The whole group is steam-cured for 16 hr., after which 20 pipes are removed and 20 new pipes set and

subjected to another 16 hr. of steam-curing. In this way each pipe is cured for two days—one day in the form and one day with the form removed. When the form is removed, pockets and voids are filled with neat cement mortar.

The steel sleeve, 12 in. wide and of ¼-in. metal with 1-in. flanges turned up on each end, bonded on the pipe serves as a bell (Fig. 10). On the inside of the sleeve 4 in. from each end, are welded two half-round stopper rings to provide a stop for the rubber gaskets (Fig. 11).

As the pipe sections are removed from the pouring rack they are either loaded on trucks for delivery or stored in the yard.

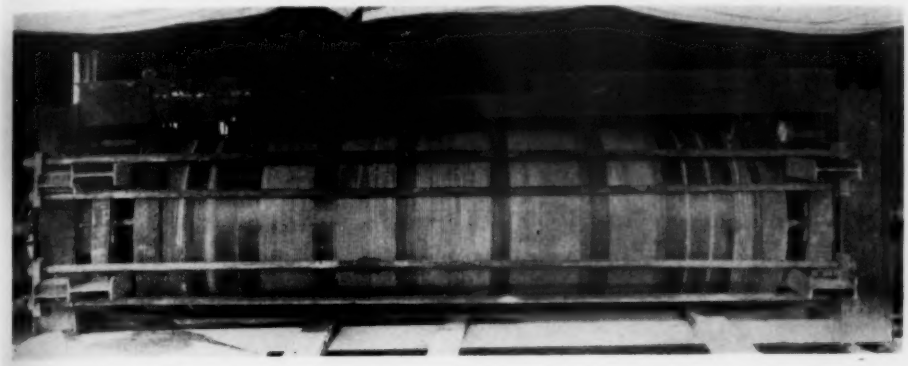

FIG. 7. Pipe Section in Testing Apparatus

FIG. 8. Pouring of Concrete Protective Coating; showing forms set to receive concrete and sections already coated

FIG. 9. Spigot End of 36-Inch Concrete Pipe Section; showing tapered end upon which rubber gasket is sealed

FIG. 10. Bell End of 36-Inch Concrete Pipe Section; showing steel sleeve with protective coating and gasket stopper ring

Strain Tests

Professor Crepps of the Purdue University Testing Laboratory made a strain test of a three-day old 36-in. pipe which had been wire wrapped but not coated. This pipe was placed in the hydraulic testing apparatus and a Huggenberger strain gage attached to the wire wrapping (Fig. 12). When internal pressure was built up to 200 psi., the gage indicated that the stress in the prestressed wire was increased by 6000 psi., bringing total stress to 96,000 psi. The ultimate strength of the wire is 210,000 psi. and the yield point 160,000 psi. It was also found that the compression stress in the concrete was reduced from 1500 psi. to 300 psi. Professor Crepps reported that a pressure of 230 psi. would result in tension in the concrete. He indicated that raising the pressure to 275 psi. would overstress the concrete in tension and would without doubt produce cracks, but that, after the pressure was released, the cracks would close up and heal.

Cutting in Connections

The provision of unforeseen additional connections to cast-iron feeder mains has been readily accomplished without interruption of service, by means of a sleeve-type patent connection. No record of such experience with reinforced concrete pipe was found, so experiments were undertaken to determine whether or not it was feasible. The problem appeared to be to obtain a cutting tool that would cut a hole in the concrete and through the steel wire wrapping. After consulting machinists, tool makers and welders it was decided to use one of the high carbon steel shell cutters and tip the teeth with stellite, which material was represented to be one of the hardest available metals.

For the experiment, a 36-in. concrete pipe was set up near the testing apparatus and a 42x8-in. "Mueller" split-sleeve connection set on the pipe. The sleeve was run solid with lead and calked. The 8-in. valve was inserted in the opening in the sleeve and also run solid with lead and calked. An air-driven cutting machine was then attached and the cutting started. When the machine had cut in about an inch, it was found that the feed shaft would not travel further without stalling. Examination of the cutter revealed that the cutting edges of the teeth had turned over, the wires having dulled the teeth without being cut. It was observed, however, that the 1-in. pilot drill in the center of the machine had cut through a wire and had advanced about an inch into the inner shell. Upon this basis it was decided to re-

FIG. 11. Insertion of Rubber Gasket in Steel Sleeve

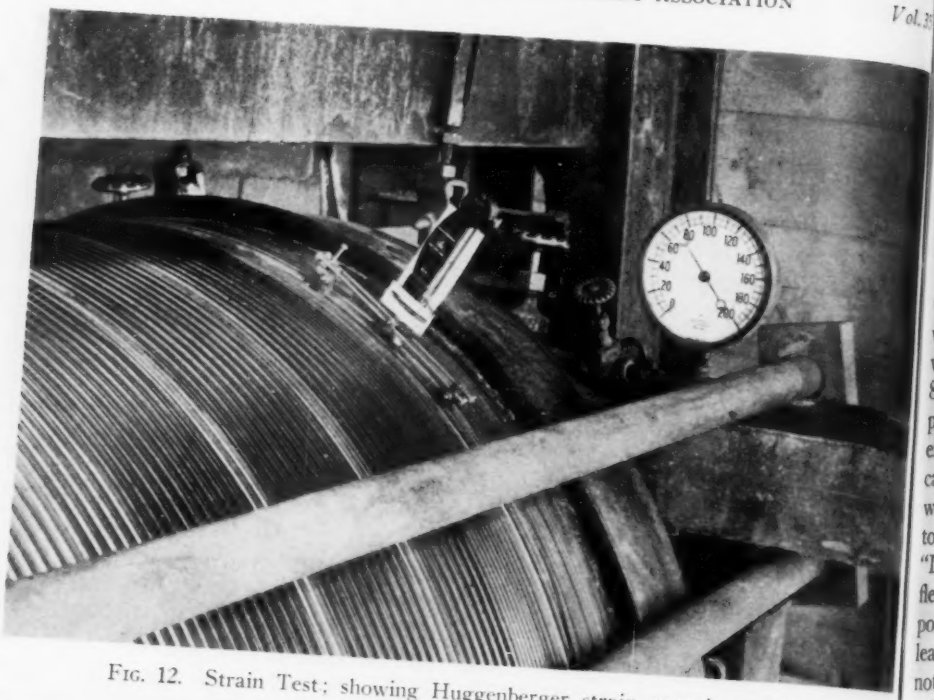

FIG. 12. Strain Test; showing Huggenberger strain gage in position

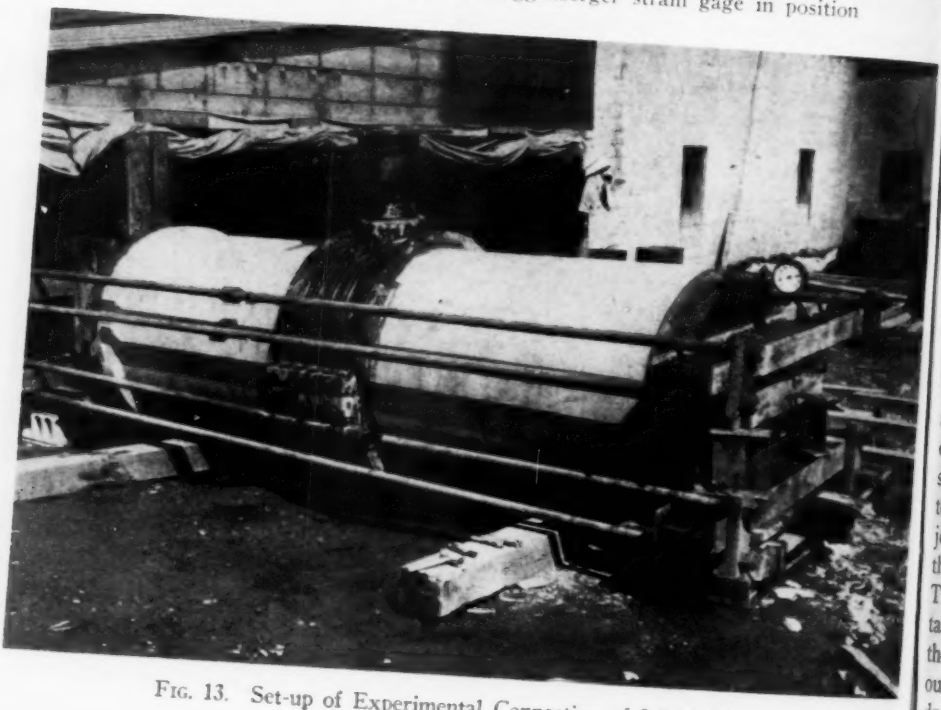

FIG. 13. Set-up of Experimental Connection of 8-Inch Line

move the cutter and use the pilot drill alone to cut through the wall, using this hole as a center from which to hand-cut the hole from the inside of the pipe. When the wires were exposed they were cut with a torch and the 8-in. hole was complete.

Another purpose of the experiment was to determine whether the pipe would hold 200 psi. pressure with 14 wires cut off. To make this test, the 8-in. valve was closed, bulkheads were placed on the ends of the pipe and eight 2-in. rods were used to hold the caps on (Fig. 13). The pipe was filled with water and the pressure built up to 180 psi. at which point the 8-in. "I" beams over the end started to deflect. With the pressure held at this point, a slight seepage at spots in the lead joint was found but no effects were noticeable in the pipe.

Thus, the experiment demonstrated that this type of pipe offers no serious difficulty to the provision of additional connections. Further efforts will be made to find a cutter that will cut the wires, and, until such is found, it is planned to use the following procedure in making connections:

The patent connection sleeve is to be set on the pipe and the lead joint run. Then, without setting the valve in the opening, the outer wall of concrete is to be hand-cut and the wires exposed. The wires are to be cut with a torch and the pieces removed. It is expected to do this with the city pressure on the main. The valve is then to be set in the opening, locked in the joint and run with lead. Following this, all the lead joints are to be calked. The cutting machine is then to be attached to the flange on this valve and the 3-in. inside wall of concrete cut out. Finally, the cutter is to be withdrawn and the valve closed. It is expected that the concrete disk will be withdrawn with the cutter. This operation is to be carried out as an experiment in the near future at the plant of the Lewistown Pipe Co. under about 70-psi. pressure.

Inspection

The manufacture of the pipe was carried on only in the presence of a city engineer. This engineer was given a list of instructions as to the inspection to be exercised. Each day he reported on the various operations or steps completed on each pipe section, which was then numbered inside and outside for identification.

Delivery

The manufacture was started on November 30, 1942, and the required number of pipe sections (950) completed April 26, 1943. The average output of completed sections was a little over eight per day through a severe winter. It was thought advisable not to deliver the pipe sections on the job site before the construction was to start, as it was feared that the spigots might be damaged by children. These fears were groundless, however, as no pipes were damaged after delivery. Delivery was started on March 25 and completed on May 27. When necessary, the delivery was at the rate of 30 pipe sections per day.

The job site was 16 mi. from the manufacturer's plant. Delivery was made by two long flat-body trucks each equipped with a power winch behind the cab. Each truck carried three pipes as a load, each pipe weighing 7000 lb. The unloading was accomplished by hooking two 6x6-in. skids securely against the side of the truck. A snatch block was fastened to the side of the truck opposite the middle of the pipe

and a cable was run from the winch through the block, a few turns being taken on the pipe. The delivery side of the truck was jacked up with two 2-in. pipes and the end of the cable was fastened to the far side of the truck. The pipe blocking was then removed, the pipe pinched over to the edge of the body and, through the brake control on the winch, rolled down the slide to the ground. This worked so satisfactorily that only two pipes were damaged in delivery.

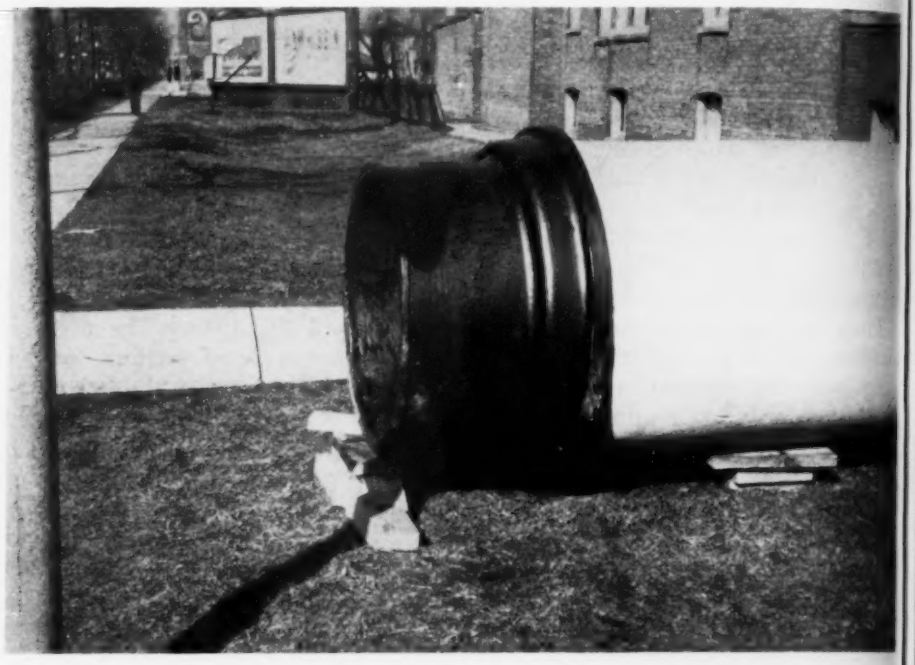

FIG. 14. Transfer Special for Connection of Concrete and Cast-Iron Lines

Preparation for Laying the Pipe

The pipe was to be laid in Rockwell Street to connect the 48-in. pipe in 50th Street to the 36-in. main in 67th Street, between the curb and the sidewalk on the east side of the street. Connections between the existing cast-iron mains and the concrete pipe were to be made by specials of bell and spigot ends (Fig. 14).

Work on the project was started as soon as the frost was out of the ground, on March 29 (Fig. 15). The equipment consisted of the following units: an "Austin" trenching machine, to cut a trench 5 ft. wide and 7 ft. deep; a gasoline tractor crane to handle the pipe; an air compressor with two concrete breakers to prepare street crossings and cross-walks; a tractor crane for backfilling the trench; an automobile crane for filling utility trenches ahead of the trenching machine and for loading surplus. Since this was the first experience of the Chicago department with this type of pipe, a set of rules for laying the pipe was developed and sent out to the foreman on the job. These rules are reproduced in the Appendix, p. 1278.

FIG. 15. Four Views of Rockwell Street Project: *Upper Left*—Swinging pipe into trench with 2-in. rope sling; *Upper Right*—Preparing to enter pipe; *Lower Left*—Pulling the pipe home; *Lower Right*—Sealing the joint

Trench Preparation

The fronting property was completely built up with residences and apartment buildings. The water service pipes were lowered below the trench depth in advance of the digging machine. The gas services were dug up in advance, cut and equipped with a union by which a section of the pipe as wide as the trench was removed just in advance of the trencher. In general there were no obstructions to the digging machine. The soil was medium hard clay and the banks stood up fairly well, but the top 2 ft. was sloped and was also hand dug in advance under street car tracks. Notwithstanding these difficulties, on the average, 277 ft. of pipe per day was laid. On the maximum day, 624 ft. was laid. The pipe-laying forces have experienced no difficulty because of the type of pipe and the engineers are favorably impressed with the ease of handling and making up the joints (Fig. 16).

Field Testing

After 4000 ft. of pipe had been laid, hydraulic testing of the pipeline, as provided in the specifications, was attempted on the first valved section of 2600 ft. The 24-in. valves were closed and braced with 6x6-in. timbers against the banks of the trench and the valve north at 63rd Street was also backed up by about 60 ft. of cast-iron pipe with lead joints. The pipe section was provided with 1-in. taps inserted in the sleeves at several high spots to let out the air. A valve on a connection was opened to fill the pipe and, after the air was all out, the taps were closed and the city pressure of 37 psi. was put on the section and allowed to stand for

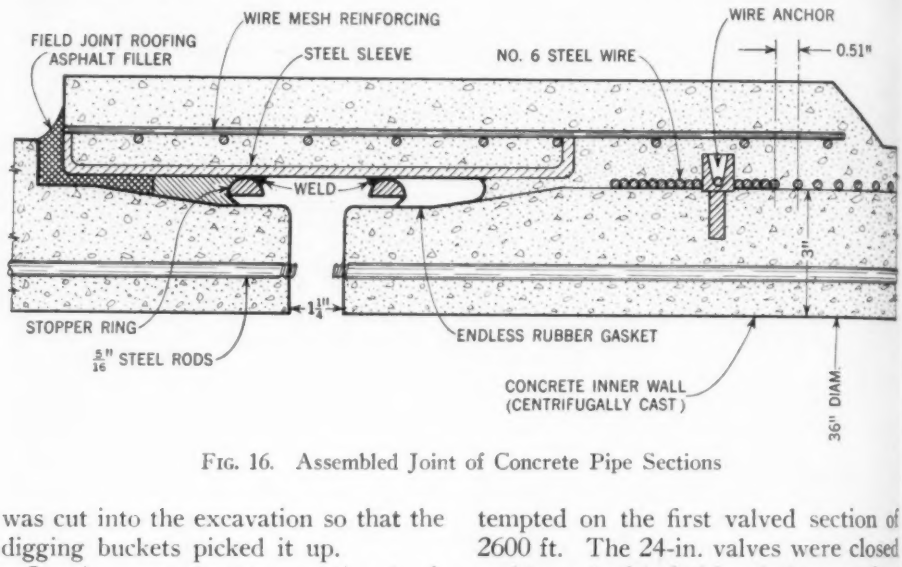

FIG. 16. Assembled Joint of Concrete Pipe Sections

was cut into the excavation so that the digging buckets picked it up.

In the cross-streets, at the ¼-mi. points, a water main, a gas main and telephone and power cable in conduits all crossed the line of the trench. In most cases, the water mains and gas mains were lowered or raised, so they would not block the pipe. Where cables were found, the trench under them was dug by hand and, when the pipe was laid up to this hand trench, it was lowered by use of 1 : 16 bends to go under the conduits. The trench

24 hr. The connection valve was then closed and one of the taps opened to test the shutdown. No water was found leaking into the section, so the tap was closed. Water through the connection valve was then bypassed through a 1-in. meter and, after the pressure of 37 psi. was restored in the section, the meter was rated. The flow was found to be 400 gpd., which is equal to 22 gpd. per inch-mile.

The testing truck pump was then used to pump up the pressure. There had been doubt in the minds of the testing engineers whether the valve on the north end of the section was sufficiently blocked to withstand pressure up to 150 psi. without moving. Accordingly, a check mark was made on the pipe and a transit line fixed on the mark was observed while the pressure was being built up. When the pressure was up to 85 psi., it was noticed that the pipe moved about $\frac{1}{4}$ in. and that the joint just north of the mark moved about $\frac{3}{8}$ in. indicating that the valve moved $\frac{1}{2}$ in. The engineer decided that it was unsafe to apply any greater pressure under the conditions, so the pump was shut down and the supply valve closed. The pressure on the main was observed for 35 min., during which time the pressure dropped to 55 psi. Subsequently, the pressure was reduced to city pressure of 37 psi. and a meter rating was again taken for 20 min. No flow was indicated.

The pipeline was tight under 37 psi. and the ultimate test was deferred until another section of pipe was completed, when the city pressure could be exerted as a counterpressure and the blocking could be made more secure. It is to be noted that, although one joint moved out an indicated $\frac{3}{8}$ in., no leakage occurred at this joint. There is evidence that the imposition of the 85-psi. pressure either forced out some air that was pocketed or tightened up a gasket or gaskets, by which the 400-gpd. flow registered on the first test was eliminated. The gaskets have a feather edge which is exposed to the pressure, and the pressure tends to force the gaskets against the pipe, which would stop any slight leakage. Later on another section was completed and both were tested under 105 psi. and found to be without leakage.

Summary of Work Completed

At the time that this paper was prepared, the pipeline had not been completed, half a mile remaining to be laid. No section had been tested under 150-psi. pressure as provided in the specifications and the cost accounting was incomplete. It is expected that the cost of the pipe laid will be $5 per foot less than 36-in. pipe has usually cost the city. The pipe is readily laid and when the spigot is entered into a bell the joint is made. The joint is flexible and is able to withstand reasonable settlement or vibration without joint leakage. No difficulties have been experienced with reduced carrying capacity due to incrustation in the past, so the concrete pipe will not have much added value on that account.

As noted earlier, all pipe laying in Chicago is done by the forces of the Dept. of Public Works, of which O. E. Hewitt is Commissioner. Immediate construction was under M. E. Boylan, Dist. Supt., and J. B. Eddy, Asst. Engr., both reporting to B. W. Cullen, Supt. of the Water Pipe Extension Div. One of the writers, W. B. Weldon, prepared the specifications and was in charge of the inspection of the pipe plant.

Appendix

Instructions for Laying 36-Inch Concrete Pipeline

Specifications Covering the Purchase of the Pipe

A contract was let to the Material Service Corporation on October 16, 1942, to furnish approximately 11,244 ft. of 36-in. reinforced concrete pipe. This contract also provided for a certain number of the castings required. These contract castings have been requisitioned and will be delivered on the job. The balance of the castings required are to be furnished by the pipe yards on requisition.

The contract provides for the furnishing and delivery of the pipe and necessary appurtenances, such as sleeves and lead or rubber gaskets, that are required to assemble the pipe or fittings in the trench.

The pipe is to be laid by the regular Water Pipe Extension Division forces, and the responsibility for the pipe by the city begins with the delivery of the pipe on the street in good condition as accepted by the pipe inspector. Following are two sections of the contract specifications that apply to pipe laying:

Field Tests: After each section of pipeline (approximately ½ mi.) has been laid, the section will be filled with water and then subjected to a hydraulic test of 150 psi. pressure. The total leakage under this pressure shall not exceed a rate of 5400 gpd. per mile of pipe for types "C." All defective materials shall be repaired or replaced in the line at the expense of the Contractor, and the tests shall be repeated until the above conditions of allowable leakage are met.

Inspection of Pipe Laying: The Contractor is to furnish an Engineer or Inspector who is to be present when the pipe or fittings are laid. His duty is to supervise the assembling of the joints and the handling of the pipe in laying. The City will do this work to the satisfaction of the Contractor's inspector and will not be responsible for the Contractor's guarantees under these specifications. The presence, supervision and direction of the Contractor's inspector, and the City's recognition of his authority as the representative of the Contractor, shall be considered sufficient assurance that the Contractor's guarantees have not been adversely affected during the laying of the pipeline.

The field test is to be provided for by the city's forces and two lengths of pipe, with sleeves tapped for 1-in. taps, will be provided for each section (valve to valve). These taps will provide for the pump connection and air vent. Each section is to be tested as soon as possible and backfilling is to be deferred until the section is satisfactorily tested according to the specifications.

Particular attention is called to the section "Inspection of Pipe Laying." It was the intention that the contract specifications were to assure that the contractor would furnish pipe and joints that would withstand the test provided after the pipe was laid. In order to avoid any possible claims by the contractor that failure to withstand the test was due to neglect to install the pipes properly, this section of the specifications provided that the contractor would furnish a competent representative to supervise the handling of the pipe and the assembling of the joints. The city foreman is cautioned that, in these two functions, he should be guided by the experi-

enced opinion of the contractor's representative. In case of a difference of opinion in regard to some vital matter, the foreman should get in touch with the superintendent and obtain further instructions.

Pipe-Laying Regulations

Handling Pipe: Avoid rolling the pipe over uneven surfaces. Use a rope sling or a band sling in handling the pipe. Do not use a wire cable.

Avoid bumping the pipe. Use a board in front of the bell of the pipe when lowering a pipe to be set. This will serve as a bumper in the event that pipe swings against pipe that is laid. A 12-ft. length of concrete pipe weighs approximately 7000 lb.

Preparing the Trench: The pipe is to be laid with a normal cover of not less than 2 ft. and the ditch should be approximately 7 ft. deep and 6 ft. wide. The pipe should be set on double blocking, one set of two pieces of $2 \times 12 \times 2\frac{1}{2}$ ft. to be placed 2 ft. in back of the bell and one set 3 ft. ahead of the last bell. The blocking should be firmly bedded and should be at a proper elevation so that the pipe will be at approximately the proper grade when resting on the blocking.

Providing the Joint: Before a pipe is lowered, the bell in the pipe already laid should be brushed out clean and the hand should be run around the sleeve to assure that no particles are left in the bell to prevent the even seating of the gasket. The gasket should then be examined to see that it is free from stones, sand or dirt, inserted in the sleeve and pushed firmly against the stopper ring in a flat position. The pipe is then to be lowered and set on the blocking with the spigot end about 2 ft. from the bell; the beveled spigot should be brushed free of all uneven particles, after which it should be painted with a soapy solution to provide for easy sliding. The pipe is then to be entered into the bell carefully and the spigot is to be kept centered in the bell as the pipe is pushed home in the gasket ring. An inspection is then to be made of the joint, both inside and out, to detect any evidence that the gasket is rolled or uneven or that any part of it has passed the gasket ring stopper.

Setting the Pipe: After the pipe is temporarily set, two wedge blocks are to be set on the blocking at the bell end and driven in firmly so that the pipe is bearing on the wedges. Two wedges are then to be set on the rear blocking end, driven in firmly so that the pipe is raised off the metal sleeve and is supported on the wedges. A close inspection must again be made of the joint, both inside and out, to detect any evidence that the joint is faulty.

While the trench is being dug, the anchor chains for the chain jacks should be attached to the last pipe set in the trench.

Having determined that the pipe is properly set, the chain jacks are to be attached and, with a $6 \times 6 \times 60$-in. timber set across the face of the pipe with the jack chains attached, the pipe is to be pulled into the joint evenly until it is firmly seated and until the distance between the ends of the pipe is close to $1\frac{1}{4}$ in. and uniform at all points, unless the pipe is to be set out of line or grade. The maximum amount of swing in a 12-ft. length should be 1 in. The chain jacks will be furnished by the contractor.

Sealing the Joint: After the pipe is permanently set and two pipes are set in advance, the third joint back is to be sealed on the outside by running with a hot fluid roofing asphalt. An asbestos roll is to be tightly drawn in front of the joint and clayed up to prevent leakage, after which the hot asphalt is to be poured into the joint and allowed to cool and set before removing the roll. The joint inside the pipe should be left open.

Backfilling: The backfilling material to be used below the center of the pipe is to be of fill sand. This is to be placed after the pipe is satisfactorily tested. The estimated amount of sand required is 3½ cu.yd. per length of pipe. After the sand fill is in place, it is to be flushed with water to pack the sand against the pipe. The amount of surplus to be disposed of is estimated at 1 cu.yd. per lin.ft. After the trench is backfilled, it should be puddled in the usual manner. Each pipe has been numbered, both inside and outside, at the plant. The pipe should be laid with the number on the top of the pipe and the foreman is to report the pipe numbers in the order laid, in his daily report. He should also show on his report the pipe number of the pipe laid at the north line of each intersecting street.

It is the intention of these instructions to cover points that are new to the Water Pipe Extension forces because of the introduction of concrete pipe which has not been used in the water distribution system before.

B. W. CULLEN, *Supt.*
Water Pipe Extension Div.

Outline of Installation Procedure for Steel Water Pipelines

By William W. Hurlbut

ONE of four chapters scheduled to be included in the American Water Works Association *Manual for Design and Installation of Steel Water Pipe Lines,* is "Installation of Steel Pipe." It is believed this chapter (IV) should include the following sections: (1) Transportation and Handling, (2) Excavation, (3) Joints; Field Welded, Mechanical Couplings, Bell and Spigot, and Other Types, (4) Anchorages, (5) Laying, (6) Miscellaneous, (7) Backfilling.

Transportation and Handling

This topic, in respect to enameled pipe, was presented at the Chicago Conference in 1942, by Deming Bronson and George B. McComb, and published in the A.W.W.A. Journal of May 1943. The Barrett Division of the Allied Chemical and Dye Corporation, with the approval of the Water Works Practice Committee and Subcommittee 7-A, Steel Water Pipe, of the A.W.W.A., has republished the paper in the form of a water works manual which I highly recommend. This document will serve as a guide to contractors, purchasers, and inspectors. Inasmuch as transportation and handling have been thoroughly covered, my remarks on this subject amplify what previously has been covered.

It is highly essential that all pipe should reach the trenchside in perfect condition. All enameled pipe must be handled only by means of approved hooks on the ends of fabric slings (Fig. 1). The fabric slings should be of fabric belting of a minimum width of 3 in. for loads of less than 1,000 lb., with an additional width of 1 in. for each additional 1,000 lb.

Trucks and trailers used for transportation of pipe should be provided with padded bolsters curved to fit the diameter of the pipes. Heavy approved padding should be used under load tie chains. Enameled pipe should never be placed directly on rough ground but should be properly blocked when stored at trenchside. Rolling pipe on enameled surface should not be permitted, but if the ends of pipe are bare the pipe may be rolled on sleepers on the bare places. When placing pipe in the trench, fabric slings should be used at the balancing points; the pipe should not be dragged along the bottom of the trench, or bumped; it should be supported by the sling while fitted up to abutting pipe. Inspection of the coating on the under side of the pipe while suspended from the sling is im-

A paper presented on June 17, 1943, at the Cleveland Conference, by William W. Hurlbut, Asst. Chief Engr. & Gen. Mgr., Bureau of Water Works & Supply, Los Angeles, Calif.

portant, and any injury to the coating should be repaired before lowering the pipe into the trench. The longitudinal welded seam should be approximately on top in the trench and staggered with adjacent pipes.

At all times during erection of pipeline and fittings every precaution should be taken to prevent injury to protective coating. To facilitate handling of large fittings clips should be provided.

FIG. 1. Handling 60 Ft. Length of Pipe

No metal tools or heavy objects should be permitted unnecessarily to come in contact with the finished coating (Fig. 2). Workmen should not walk on the coating except when it is necessary, and when they do they should wear shoes with rubber or composition soles and heels. Since large diameter pipe is subject to considerable traffic, heavy tar paper should be laid and maintained in the bottom of the pipe through its entire length, as long as there is need for passage through the pipe. This should apply to all surfaces whether bare, primed, or enameled. Any injury to the protective coating from any cause during the erection of the pipeline must be repaired.

Excavation

Trenches should be dug to grade as shown on the profile. Where no profile is provided the minimum cover on pipes 12-in. and smaller should be 2½ ft. in mild climates, 5 ft. in freezing climates, and on pipes larger than 12 in. the minimum cover should be 36 in. in mild climates and 6 ft. in freezing climates.

The purchaser in preparing his plans and specification should, when setting forth the payline limit for width of excavation, allow a minimum clearance

of 6 in. on each side of pipe up to 12 in. in diameter and 8 in. on each side of pipe above 12 in. in diameter.

All existing rules and regulations relating to the particular locality in which the work is to be done—in reference to protection of excavation and necessary barriers—should be complied with.

The bottom of the trench should be accurately graded by the use of a straight edge equal to the length of

FIG. 2. Lowering Tee in Place

pipe being installed and no backfilling of over excavated trench should be allowed. The bottom of the trench should be clean and free from stones and hard lumps so that the pipe will lie directly on the bottom of the trench, which should be graded so that the joints of adjoining lengths center.

Where the bottom of the trench is covered with solid, hard objects that might pentrate the protective coating, a layer of screened earth or sand not less than 3 in. thick should be placed in the bottom of the trench. Bell holes shall be provided at each joint and a hole excavated at approximately the center of each length to permit removal of the sling without damage to the pipe coating.

Joints

Field Welded Joints

Welded field joints are applicable only to large pipe because it is necessary to enter the pipe to complete the interior protective coating after the

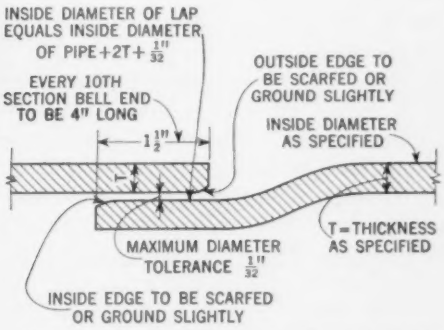
INSIDE DIAMETER OF LAP EQUALS INSIDE DIAMETER OF PIPE+2T+ 1/32"
EVERY 10TH SECTION BELL END TO BE 4" LONG
OUTSIDE EDGE TO BE SCARFED OR GROUND SLIGHTLY
INSIDE DIAMETER AS SPECIFIED
1 1/2"
T
T=THICKNESS AS SPECIFIED
MAXIMUM DIAMETER TOLERANCE 1/32"
INSIDE EDGE TO BE SCARFED OR GROUND SLIGHTLY

FIG. 3. Type of Slip Joint for Field Welding, Required for Welded Steel Water Pipe; Weld Bead on Outside of Spigot End and Inside of Bell End Shall be Dressed Down to Plate Surface for Field Joint

weld is made (Fig. 3). A 27-in. pipe is about the minimum that can be entered for this purpose and even then it is difficult to obtain a perfect job of enameling, or otherwise completing protective lining. The use of welded joints results in a very rigid pipeline that cannot later conform to any settlement of the ground. This feature is a great advantage in cases where a moderately long unsupported span is desirable, such as in crossing gullies, but it may prove to be a distinct disadvantage where a pipeline crosses filled or unstable ground.

Welded joints are also capable of resisting the thrust from closed gate valves or from angles in the pipeline. If welded joints are depended upon to transmit such thrust through a sufficient number of lengths to absorb the force in skin friction, careful computation of the thrust and strength of the weld must be made in the case of larger pipes under high pressures, to determine if the welding is sufficient to carry this load. The single lap weld most frequently used for the joints can be practically doubled in strength by welding the other edge of the lap. This must sometimes be done for a few joints away from the source of the thrust.

Pipe with welded joints when laid in a trench will usually give no trouble from thermal expansion and contraction, except during the construction period when backfilling is only partially done and the sun may cause appreciably high temperatures in the steel. It is then advisable to weld the pipe in sections of approximately 500 ft. leaving one joint unwelded. The remaining joint should then be welded in the early morning hours when the pipe is coldest and it is at a minimum length. This procedure will result in the pipeline having a minimum of temperature stress when filled with cold water.

Pipe laid on piers above the ground can be continuously welded, making special closing joints as above described, and will give no difficulty from temperature changes except when unwatered in warm weather. The expansion in length of an empty pipe above ground frequently gives a considerable amount of trouble such as lifting entirely off the piers where there is vertical curvature. The occasional use of mechanical type of joint will accommodate the expansion and contraction.

Mechanical Couplings

Mechanical couplings as applied to steel pipelines are usually rubber packed, depending for tightness on compression of the rubber in couplings of the "Dresser" type, and depending for tightness on thin flexible lips in the "Victaulic" type (Fig. 4). Couplings of the "Dresser" type may be used on plain-end pipe without any special preparation of the ends except for the omission of the protective coating for a short distance. Where long pipelines are laid above the ground

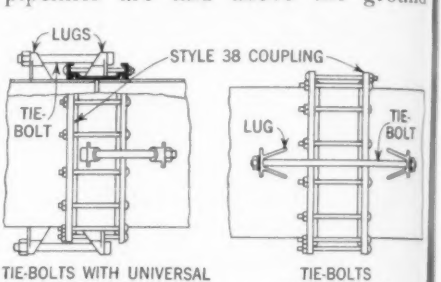

FIG. 4. Mechanical Joint Harness to Take Longitudinal Pull

with this type of coupling there is a tendency for small movements, due to expansion and contraction, to accumulate at some one coupling at intervals along the line. Alternating movements of this sort may displace a coupling longitudinally, eventually uncovering the joint unless the coupling is restrained in some manner. Such couplings, particularly in the larger sizes, are usually made with a rib on the inside of the sleeve that goes between the ends of the pipe being coupled, preventing the coupling from working off the joint. It is frequently convenient or necessary to remove this centering rib, making it possible to

slip the coupling entirely on one pipe end and then slipping it back over the joint. If contraction and expansion movements are likely to occur at such a place, the coupling can be restrained by welding clips to the pipe close to the coupling. The welding of such clips can easily result in sufficient heat in the pipe to destroy the protective lining when the pipe is dry; but after the pipe is filled and water is flowing through, electric arc welding can be done on the pipe if care is used to reduce the concentration of heat by taking plenty of time and using small rod with low welding current. The "Dresser" type of coupling cannot be depended upon to take any tension. Therefore it will not resist the thrust of a shut gate valve or an angle in the line. Other provisions must be made to resist these forces, such as long through bolts engaging clips of the pipes, on each side of the coupling, or the anchoring of a gate valve to an independent foundation.

Couplings of the "Victaulic" type require the use of a groove in the end of the pipe for the coupling band to engage. This type of coupling provides for a small amount of longitudinal movement in each joint and resists tension that tends to separate the pipe sections after this small longitudinal movement is taken up. It requires the use of a heavy grooved adaptor band at each end of each section of pipe when the pipe wall is thin. Other types of end treatment are recommended by the manufacturers of these couplings, such as upsetting a slight flange on the end of each pipe section.

Mechanical joints are flexible and will remain tight during considerable movement that might result from the settlement of filled ground, etc. They are also adaptable to laying pipe on long curves.

The application of protective coatings to mechanical couplings is something of a problem. It is difficult to get into the many angles and completely around the bolts when daubing enamel with a brush. The use of a special form of sheet metal to clamp around the coupling, provided with a pouring gate at the top and a valved drain at the bottom, has proved very satisfactory. Hot bituminous enamel is poured into the form to fill it completely and then is drained immediately at the bottom, leaving all parts entirely coated and recovering all of the enamel that will drain out. No retouching of the pipe lining is necessary; hence mechanical couplings are especially useful on small pipes.

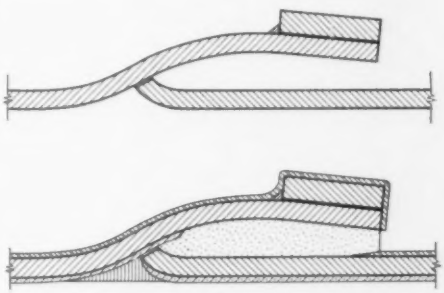

FIG. 5. Reinforced Expanded Bell of 31.40-In. Steel Pipe of Harbor District Trunk Line; *Top*—for Cement Joint; *Bottom*—Showing Enamel Coating and Cement Joint

Bell and Spigot Calked Joints

Bell and spigot calked joints can be used to advantage in joining sections of heavy gauge pipe (Fig. 5). Since no heat is applied in making the joint, the lining of the pipe can be completed before it is laid and there is no need to enter the pipe for patching at the joints. The joint is calked

with moistened neat cement, usually without the use of any yarn or packing at the bottom of the joint. Such a joint, once made, is not rigid and will not remain tight if movement due to settlement occurs. Pipe with such joints can be laid in curves. The extreme deflection in any one joint is reached when the spigot becomes very nearly parallel to the line of the taper in the bell which locks the cement in the joint. A shorter radius of curvature has been gained in many instances by trimming back the lip of the spigot on the outside of the curve, thus allowing better centering of the spigot in the bell. Joints close to the point of laying pipe should not be calked immediately since bumps and strains from placing pipe may be transmitted through two or three lengths of pipe and disturb the freshly calked joint. Each length of pipe when placed and pressed home in the bell should be anchored by rough backfilling for most of its length, leaving the bell hole open for making the joint. Because of the small moisture content in cement for calking (16 per cent by weight), care must be exercised to protect the cement from drying out quickly. It is frequently necessary to provide shade over the joint because of the length of time required in going around a joint in large pipe. Wet sacking placed over the joint will provide a cool, moist atmosphere, but water should not be poured on this sacking until the cement has definitely set, since running water will quickly wash out the cement. Protective coating must be repaired on the outside where a cement joint is made, but the exposed face of the cement must not be enameled over. Transmission of moisture through the cement will cause blisters if it gets under the enamel.

A cement jointed pipeline can be filled with water without pressure 12 hr. after making the last joint, and regular line pressure can be applied in 24 hr.

Lead or other melted joint compounds may also be run in bell and spigot joints in the same manner as in cast iron pipe, but in large pipe should be run from several gates starting on the sides and finishing at the top to avoid localization of heat at one gate which will result in melting a bituminous lining.

Other Types of Joints

Riveted field joints have been used on welded steel pipelines in a few instances, but are not to be recommended. In making riveted joints there is considerable vibration and much tool handling that is damaging to both lining and outside coating. On smaller sizes of pipe it is impossible to properly repair damage to the lining. Flanged joints are especially useful at valves and in pipelines laid in long spans on piers. In making flanged joints the lining is not damaged in the process. The bolts and exposed flanges surfaces are easily covered with a protective coating. The attachment of flanges to both ends of the pipes usually involves many times the amount of welding required in making welded slip joints. Flange coupled pipe is very rigid and small angles in alignment entail considerable work in cutting and accurately positioning the flanges.

Drive joints can be recommended only for thin pipe operating under low pressure. Such a joint usually depends for water tightness on a film of softened bitumen in the joint. The heating of the pipe to soften the bitumen for the joint will frequently cause damage to the pipe lining beyond the zone

required for the joint. This type of joint will not take any tension, and lugs and tie bolts must be provided at each joint where tension might develop. Leaks are frequent if ground settlement occurs.

Laying

Unusual problems often arise in installing pipelines above the ground. It sometimes becomes necessary to install the pipe from gantries (Fig. 6). This type of construction involves accurate track laying and the installation of a cable way. The track may also be used in construction of concrete piers.

Gantries should be designed with sufficient clearance to allow the pipe section in the carrier to pass over the completed sections (Fig. 7).

Trestle and ring girder construction is often employed in highway and gully crossings (Fig. 8). Erection presents no difficult problem but every precaution should be taken with regard to closure of the spanned section.

Anchorage

The necessity for anchoring, or blocking, arises at angle points, side outlets, valves, and on steep slopes. The type of pipe joints to be used influences the extent of anchoring that may be necessary at these points.

FIG. 6. Gantry and Track for Lowering Pipe

All-welded pipelines laid in trenches will ordinarily need no anchoring except on extremely steep slopes. Under unusually high pressure conditions lap-welded joints may need reinforcement close to valves and angles of large deflection. An all-welded pipeline laid above ground on piers is also usually stable under pressure, but will require heavy anchorage at angle points and

FIG. 7. Pipe and Carrier in Place

FIG. 8. Ring Girder Construction

particularly on steep slopes to resist stresses arising from temperature changes when the pipe is empty (Fig. 9). When other types of joints are used that have little or no ability to resist tension, all of the above-mentioned critical points must be adequately blocked or anchored. To lend greater stability to angles, either in trenches or on piers, it is advisable to provide welded tangents of several diameters length each side of an angle in preference to placing flexible joints close to the angle.

FIG. 9. Concrete Pipe Anchorage

Where pipes are laid on piers several layers of heavy roofing paper should separate the pipe from the structure. Satisfactory practice is that 90 deg. of the pipe surface bearing on the pier is sufficient (Fig. 10).

Pipelines laid on slopes, particularly above ground, always have a tendency to creep down hill, with a distinct disinclination to creep up hill when conditions would be expected to result in that action. Large pipes have been been known to be crushed by direct axial compression at the bottom of a slope when upon expansion due to temperature change they were expected to creep up. This emphasizes the importance of placing immovable anchors at sufficiently frequent intervals in a long slope to reduce the weight of pipe supported by each anchorage to a safe figure (Fig. 11). For pipe laid in trenches, horizontal angles and unbalanced areas at side outlets are usually satisfactorily blocked by filling between pipe and the firm side of the trench with concrete. The area against the earth, computed on the estimated safe bearing load of the earth, will usually result in a sufficient bearing against the pipe. Vertical angles with resultant thrust in a downward direction require

FIG. 10. Protection to Pipe Over Pier

FIG. 11. Pier and Anchorage Construction

no special treatment if the pipe is laid on a firm and carefully trimmed trench bottom. Vertical angles with a resultant thrust upward must be anchored. Such an anchor may be cast of concrete surrounding the pipe with sufficient reinforcement to transmit the uplift to the lower portion of the anchor, or may consist of a concrete block entirely below the pipe with a band or U-bolt tying the pipe down.

Where a pipeline is installed on piers the thrust resulting from an elbow or a slope generally tends to overturn the anchor pier. The design of such a pier is closely related to the design of a gravity dam section.

Valve Installation

Main line valves in pipelines larger than 12-in. are usually of a smaller size than the main. The reduction in size is dependent upon the friction loss that can be allocated to the valves out of the total loss permissible in the particular installation. A much greater reduction in size can be made with rotary cone valves than with gate valves, with the same loss of head. The reducers used should be of considerable length to get the benefit of good energy recovery downstream from the valve.

Flanged valves are usually most satisfactory in steel pipelines, but hub-end valves are frequently used with good results. If the inlet and outlet sections of pipe are reduced to the normal size of the valve, it will usually be found that the sockets on valves made for use with cast iron pipe are of too great a diameter to make a satisfactory joint with steel pipe. Hub-end valves ordered for the job can be made with undersized sockets. Otherwise, the steel pipe spigots can be built up to a suitable diameter by welding a heavy steel band on the sockets.

Valves should not be rigidly bolted or joined with cement joints on both sides. It is desirable to allow some flexibility by the use of a mechanical coupling or a lead joint on one side of the valve (Fig. 12).

The weight of large valves should be supported on concrete blocks. In the case of horizontal gate valves the eccentric weight of the bonnet must also be supported. Valve foundations are sometimes designed as anchors to completely absorb the thrust resulting from closing the valves without transmitting any stress into the pipeline. If such anchoring is desired it is necessary to have the valves manufactured with a suitable base. It has been the common experience of water works men that large gate valves are extremely difficult and sometimes impossible to operate under extreme conditions of unbalanced pressure such as occurs when a pipeline breaks. Improvements in the construction of gate valves, such as fully machined gears in grease retaining cases, have alleviated this difficulty.

Large valves are usually constructed so that they can be installed in the ground without elaborate vaults. Working parts such as the gear box and stem packings frequently can be made easily accessible through a relatively small chamber or casing. The necessity for large vaults enclosing the entire valve should be weighed against the frequency of actual use of such large vaults for dismantling or removing and replacing valves.

Vaults and Manholes

Manholes for gaining access to the packings of valves often can be no larger than the ordinary sewer manhole. The casing frequently consists of brick, concrete, or a section of old pipe. Care must be taken to avoid

strains in the valve or pipeline by the transmission of traffic loads from the surface. The manhole casing should stand on its own foundation and be constructed with a clearance of an inch or more from the equipment enclosed. Where large vaults are used, completely enclosing a valve or manifold, the structure is usually of reinforced concrete. Rectangular structures require considerably more wall reinforcement than circular structures and sometimes do not provide any more working space. Access to a vault is usually through a manhole in the roof. There is always the likelihood that valves in a vault will have to be operated with the vault flooded. Therefore, small openings provided with removable caps should be provided over each valve stem. The vault roof may be constructed monolithic with the walls, in which case it is often desirable to provide a larger opening than the common manhole of 20 to 24 inches. An alternate construction that has been found very convenient provides a roof of removable slabs of reinforced concrete that may be removed by a hoist, giving entirely free headroom. Such a roof may be in sections, keeping the weight of each section low enough for easy handling. Consideration should be given in vault design to continuous ventilation, collection and removal of water, and lighting.

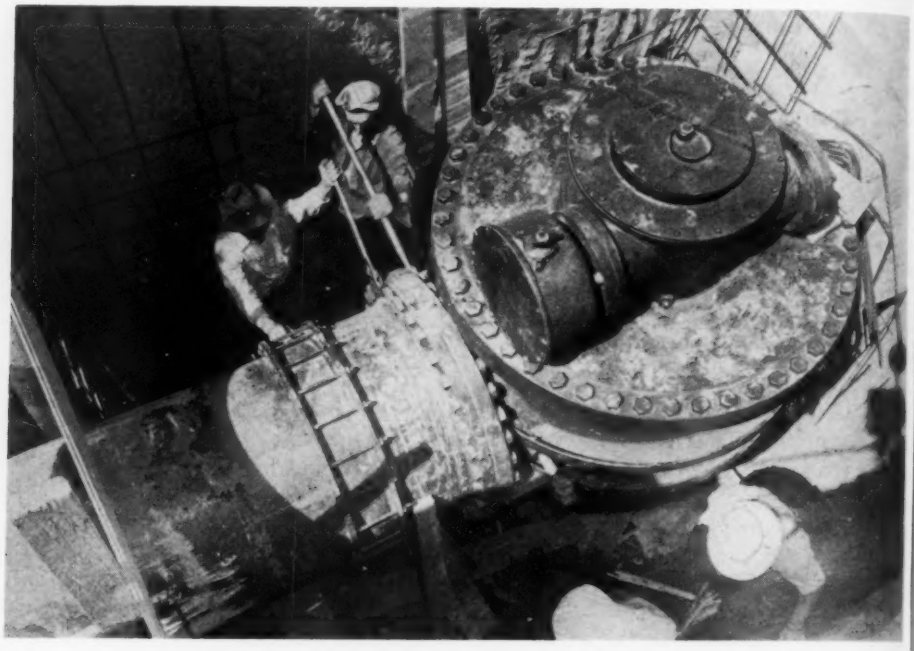

FIG. 12. Dresser Coupling for Rotovalve

Miscellaneous

Main line meters fall generally into three classes: those actuated by differential resulting from a change of velocity of the stream; those operated by direct velocity head; and those operated by a moving velocity element such as a propeller. Each has its points to recommend it, such as accuracy at a

particular flow, reasonable accuracy through wide variation of flow, cost of installation, ease and accuracy of recording instantaneous flows or ease of accuracy of recording total quantity. In selecting meter equipment these points should be considered and should be made on the basis of what is most desirable in the particular installation.

Air valves have three primary functions: to release air while filling the line; to release continuous air accumulations in a high spot; and to admit air for the relief of vacuums. For the first function, hand-operated stop cocks or valves at high points in a relatively flat line are sufficient. Where summits are more pronounced and the pipeline velocity at times may be low, automatic air release valves should be provided. These will continuously release any air accumulations while the line is under pressure. To provide for the quick admission of large quantities of air to avoid collapse of a pipeline, automatic air and vacuum relief valves are installed at summits. Such valves also automatically discharge air while the pipeline is filling. Automatic valves must be placed in an accessible location and frequently tested or they may fail to perform their intended function in an emergency. If they are housed in a box or vault, vents of greater capacity than that of a valve must be provided.

In localities where frost is severe or freezing weather occurs, special attention must be given to the housing of air valves and other appurtenances to avoid freezing. This matter assumes considerable importance where pipelines are installed above ground. A relatively mild frost, while not severe enough to completely freeze up an air valve, can result in sufficient freezing of a film around the seat to prevent operation of the valve in an emergency.

Backfill

Selected backfill material free from boulders, rock, or other unsuitable substances, should be deposited in the trench on both sides of the pipe to an elevation of about 8 in. above the top of the pipes up to 12 in. in diameter, and not less than 6 in. above the horizontal center of pipes with diameters greater than 12 in., joints to be left exposed for examination during pressure tests. The backfill shall be tamped in thin layers under and on each side of the pipe, to provide a compacted backing against the external surface of the pipe.

The upper portion of the trench backfill may contain coarser material but should be free of brush or objectionable matter that would cause proper consolidation and resultant settlement. This portion of the backfill should be flooded or puddled. Precaution should be taken to prevent floating of the pipe when flooding the trench.

Field Tests

After completing the installation of a pipeline, or a section of the line between valves before the joints are covered, a hydrostatic test of the line should be made. This test is primarily for the purpose of determining if the field joints are tight, since each section of pipe has been tested for bursting at the plant. The field test is usually satisfactory at the regular working pressure of the line and the pressure applied should never exceed 150 per cent of the working pressure. A reasonable time for the curing of cement blocking and piers must be allowed before a test is made. When filling the line care should be exercised to remove all of the air. After filling the line it may be necessary to use a

small pump to raise and maintain the desired pressure. If the line is adjacent to an existing system the regular working pressure can be applied by connecting to the existing system without a pump. A small water meter that has been carefully fitted up to give good registration for small flows can be used to measure the aggregate leakage.

Allowable Leakage

If a test with pressure higher than the regular working pressure is to be made, the pressure should be sustained by pumping for a period of about ½ hr. After that the regular working pressure should be maintained while all joints are carefully inspected for evidence of leakage. The amount of leakage that can be permitted depends on the kind and number of joints. An all-welded pipeline should be bottle tight. Pin-hole leaks that may develop in the field joints should not be stopped by peening. They should be marked for proper repair by welding and can frequently be welded by relieving the pressure without emptying the pipe. No leakage should be allowed from mechanical joints. Cement joints will frequently weep slightly during the first two weeks. Such weeping will usually stop in that time. A leak that is serious enough to squirt even a very fine stream will probably increase in size and must be repaired. An allowance for leakage of 25 gal. per in. diam. per mi. per 24 hr. is a liberal allowance for field jointed pipe in 20-ft. to 30-ft. lengths.

Tests of a 31-in. cement jointed pipeline 63,200 ft. in length resulted in a leakage of 3.24 gal. The greater majority of the 2,100 joints were tight and the leakage was found to be concentrated in a very small number of joints.

Joints made with sulphur compounds show a rather high leakage for a number of days. The majority of the joints take up in about two weeks so the leakage tests are frequently not made until after the line has been under pressure for that length of time. Any leaks still freely flowing will probably not take up and must be repaired.

Field Welding of Steel Water Pipe

By H. Arthur Price and G. H. Garrett

NOT so many years ago, the users of welded products were few in number, water utilities being among the pioneers to install welded steel pipe lines and tanks. The early processes used, the equipment employed, and the resulting products were often not acceptable. Today, however, welding is a commonplace, the products are unquestioned and there are few industries that do not use welded products in some form.

The utilization of field welded joints in the installation of steel pipe (Fig. 1) is becoming more universal. The fact that field welding of steel water pipe joints must be done manually (due to the circumferential weld being made with the pipe in place and that this weld is a difficult one to make) has limited the complete use of welded joints because of the lack of qualified operators.

After the war, it is expected that with the return of welders from the shipyards and aeroplane factories to their homes throughout the United States, qualified welders will be available. Realizing this, the American Water Works Association, in conjunction with the American Welding Society, has formed a joint committee to prepare specifications for the "Field Welding of Steel Water Pipe Joints," under the chairmanship of W. W. Hurlbut. These specifications for field welding will complete a pattern of specifications for steel water pipe and its protection.

We believe that the general subjects to be included in specifications for field welding of steel water pipe joints should be: scope; qualification of welding procedure and testing of welding operators; filler metal; welding equipment; types of joints; fillet welds; butt welds; preparation of base metal; welding technique; inspection; repair.

It is hoped that a discussion of each topic and the problems to be considered will be of value to the Committee, and informative to the entire water works field.

Scope

It is generally understood that pipe 8 in. and less in diameter, can be welded satisfactorily and economically by the oxyacetylene process or by the electric metallic arc process. Some gas welding equipment manufacturers claim that pipe as large as 14 or 16 in. in diameter can be welded economically by either process. A new method of field welding the joints of pipe lines (known as the oxyacetylene pressure

A paper presented on June 17, 1943, at the Cleveland Conference by H. Arthur Price, Asst. Specification Engineer, Bureau of Water Works & Supply, Los Angeles, Calif., and G. H. Garrett, General Manager, Thompson Pipe & Steel Company, Denver.

FIG. 1. Welding Pipe in Trench

system) recently has been developed by the Linde Air Products Company. It is not expected that this process will be used generally until after the war.

The experience of the authors having been limited to the use of the electric metallic arc process in welding steel joints in water pipes, they will confine this discussion to that method of welding. Since field joints in water pipe lines are always manually welded unless it is possible to make a roll weld, manual welding only has been considered herein.

A completed steel water pipe line may involve steel mill pipe, steel pipe fabricated from plate, the welding-on of flanges and other accessories, all of which have a carbon content less than 0.30 per cent. For the purposes of qualifying any specification for field welding of steel water pipe joints, a top limit of 0.30 per cent carbon should be placed, or reference made to "P" No. 1—"O" No. 1 group of steels classified by the A.W.S. under the *Standard Qualification Procedure.*

Qualification of Welding Procedure and Testing of Welding Operators

Before attempting to do any welding on a pipe line a procedure must be adopted, and a method of testing this procedure and the operators who are going to carry out the procedure must be decided upon. The A.W.S. has developed and published a *Standard Qualifications Procedure* which will be found to be very satisfactory, and which is available from them. The procedure may also be found in the A.W.S. *Welding Handbook.* The overhead butt weld or fillet weld which is included should be considered in qualifying procedure and testing of operators.

In spite of the fact that it is possible thoroughly to qualify the procedure and to qualify the operator in any welding process, a great responsibility rests upon the contractor or the department which is charged with the installation of a pipe line. It must be understood at the outset that with ordinary precaution and care it is possible to obtain welded seams which will have equal or greater strength than the materials to be welded together. On the other hand, as a result of carelessness and inexperience a very poor bond between welded metals may be obtained. In spite of specifications the results that are obtained in making field welds of pipe lines depends to a great extent upon the experience and the integrity of the contractor and upon the experience of the inspectors.

There are a number of matters to be considered in connection with the qualification of operators that are not covered under the standard specifica-

tions. First, there is the important matter of the experience of the operator. For the right kind of a welding job the operator should have had several years of experience in welding materials from which the pipe line is to be constructed. Unfortunately, the word of the operator cannot always be taken as a guarantee of his experience. Many welding operators are not as competent as they actually think they are. The matter of determining the value of the operator's experience must be left to the judgment of the contractor or the welding inspector, and if either are experienced they will soon be able to weed out incompetent welding operators.

In testing an operator the A.W.S. Qualification Test should be the first, but not be the final test. We have noticed that quite often some welding training schools teach students to make coupons that will pass the necessary tests, but they do not give the students a comprehensive course in welding. If there arises a question about the experience of a welder it would be advisable to give him additional tests to be sure that he is competent to weld field joints in the position in which they are to be welded. If the pipe line is to be roll welded, then the test is simple. If, however, the pipe is made with slip joints (Fig. 2), and the welder must work under the pipe in a cramped position, or work from staging, then he should be given tests to determine whether or not he can weld in difficult positions. If there are other conditions to be met in the field, the welder should be given tests to determine whether or not he can weld satisfactorily under the conditions that he will encounter.

The responsibility of the contractor or the welding inspector does not end with the completion of the qualification test. In order to produce a perfect job, it is necessary that the contractor exercise diligence throughout the work until the completion of the job. Carelessness must be watched for continuously and checked.

Filler Metal

The proper filler metal to be used in making the field joints will have a great deal of bearing on the quality of the finished joint and its selection should not be minimized. Under no circumstance should anything but a heavy coated rod be used. If the seams are to be welded by the roll weld method, then several types of rod can be used satisfactorily. If, on the other

FIG. 2. Welding Pipe from Staging

hand, the pipe is to be welded in position, that is, by having the operator circle the pipe while the pipe remains stationary, then an all-position rod should be used. There are several A.W.S.–A.S.T.M. rods listed as all-position rods, and no doubt a satisfactory weld may be obtained from two or three different specification numbers. However, we feel that the A.W.S.–A.S.T.M. E–6010 rod gives such excellent results in all-position work on pipe lines that it is inadvisable to consider any other type of rod. In case you are not familiar with this specification number, we might state that Fleetweld No. 5, Vertex, Shurweld B, etc., are A.W.S.–A.S.T.M. E–6010 specification rods. A great many manufacturers make rods which meet with the E–6010 specifications. However, to get the best results, great care should be made in the selection of the rod.

Welding Equipment

The best type of welding equipment is the direct current generator type welding machine. The generator may either be motor driven or gasoline engine driven, depending upon whether or not electric power is available in the field. If electric power is readily available and can be had at an economical price, then it is obvious that the motor-driven generator equipment is the most satisfactory to use because the cost of operating is much less than operating the gasoline-driven equipment, and the cost of maintenance is also much less. Under certain conditions the transformer type of welding machine may be used with satisfactory results. Whichever type of equipment is used, it should be modern, in good working condition and of ample capacity.

Joints

There are several types of field joints that can be used for joining water pipe together, such as slip joints, single or double welded; butt joints; butt strap joints.

For most purposes slip or butt joints will give the most satisfactory results.

Slip joints (Fig. 3) are made by swedging out or pressing one end of each pipe section so that it fits over the adjoining pipe section, and it usually is arranged so as to lap over the adjoining section a distance of from 1½ in. to 4 or 5 in. The 4 or 5 in. length of lap is used in making closures, bends and for other special conditions.

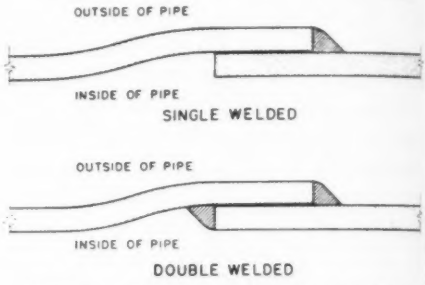

FIG. 3. Slip Joints for Field Welds

Fillet Welds

The seams of slip joints are fillet welded (Fig. 4), such welds being made by filling in the 90 deg. corner produced when one piece of metal is outside of, or on top of, another piece of metal. The welded seam is usually made with several passes, or several layers, of deposited metal. It is advisable never to fill in the proper amount of metal at one pass. A suggested contour for the fillet weld would provide an .8 throat thickness, a rounding of the top of the weld and a bottom length of 1⅛ times the plate thickness or specified size of weld.

Slip joints are seldom used where the pipe shell thickness exceeds ½ in.

Slip joints have many advantages over butt joints. First, the ends of the pipe are easier to stab or tack together because the end of the one pipe slips over the smaller portion of the other pipe, and the two pieces must come into perfect alignment. Second (Fig. 5), in case there is some irregularity in the grade of the trench, or some slight change in alignment, these changes can be taken up with the slip joints. Third, pipe which has a diameter sufficiently large for an operator to work inside (27 in. in diameter and larger, and in some cases as small as 24 in. in diameter), can be tested with oxygen or air pressure after the joint is welded inside and outside, and immediately backfilled. This oxygen or air pressure test will be described later.

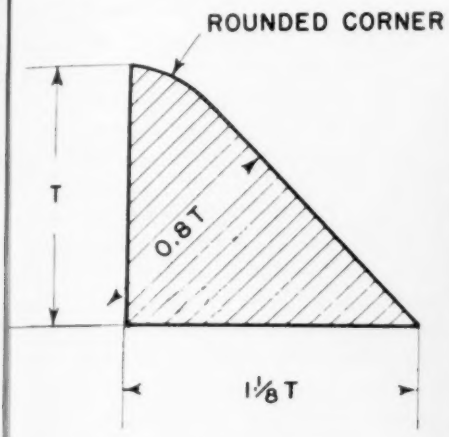

FIG. 4. Contour for Fillet Welds; T = Thickness of Plate or Specified Size of Weld

Butt Welds

The ends of pipe to be butt welded with a wall thickness greater than $\frac{3}{16}$ in. thickness should be beveled (Fig. 6). If the pipe is large enough to be welded inside and outside, then it should be double beveled; that is, it should be beveled for outside as well as inside welding. If the pipe is to be beveled on the outside only, then the entire bevel should be on the outside of the pipe. The edges of pipe to be butt welded should be carefully tacked together before welding so that there is little or no offset or misalignment in the pipe walls. Such misalignment is not good from the stress standpoint; neither is it good from the hydraulic standpoint. In order to get complete fusion through to the root of the weld, it is usually advisable to space the two ends of the pipes sufficiently far apart. The thickness of the wall, the type of rod used and the procedure will determine what this space should be. Butt joints have certain advantages and certain disadvantages; they can be used where the pipe shell is too thick for

FIG. 5. Curves in Pipeline

the use of slip joints; they have the disadvantage that they require more welding time than slip joints, and they require more welding rod.

Preparation of Base Metal

The A.W.S. typical procedure specification covers adequately the subject of the preparation of base metal.

Welding Technique

It has been our experience that downhill welding of the circumferential fillet welds of pipe is more satisfactorily than uphill welding. Corner penetration is more easily obtained and the hazard of burning away of the top of the bell is reduced. Due to the number of passes required in downhill welding an annealing effect results as each pass stress relieves the previous pass, for example: in making a $\frac{3}{8}$ in. fillet weld, welding downhill, three passes are usually made due to the small amount of material that can be deposited in each pass successfully. The same weld made by welding uphill can be made by two passes; however, the last pass deposits a heavy layer of material, resulting in locked-up stresses.

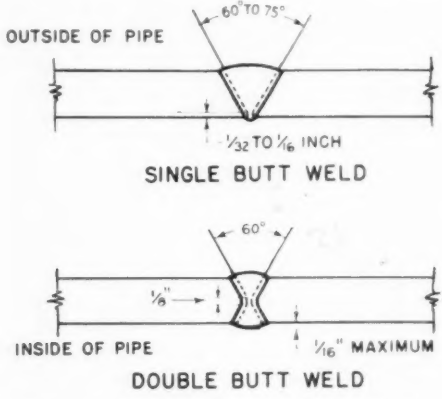

FIG. 6. Single and Double Butt Welds

Conversely, welding uphill of the circumferential butt joint is preferred to the welding downhill, due to the penetration obtained in the first pass. Also it is uneconomical to weld heavy-walled pipe downhill, due to the small quantity that can be deposited, as the thickness of the pass that can be laid down lessens as the width of the groove is increased.

Welding uphill and downhill is a controversial subject. Specifying uphill or downhill welding should not be included in the purchaser's specification but should be determined by the contractor. The contractor, depending upon the size and type of weld, may find it advantageous to make a weld by welding both uphill and downhill.

The requirements for welding in a purchaser's specification might best be accomplished by specifying the cross-section of acceptable weld, together with the minimum number of passes to be made for each size of weld. The Metropolitan Water District of Southern California includes a table in the welding requirements of its specifications, which sets the minimum number of passes for fillet and butt welds for each thickness of plate. This table (shown below) has proven very satisfactory for pipe work.

The minimum for all butt welds is not more than $\frac{1}{8}$ in. of metal deposited in each pass. In making fillet welds, metal should be deposited with the following minimum number of passes:

Plate Thickness, in.	*Minimum No. of Passes*
$\frac{3}{16}$	1
$\frac{1}{4}$	2
$\frac{5}{16}$	3
$\frac{3}{8}$	3
$\frac{7}{16}$	4
$\frac{1}{2}$	4
$> \frac{1}{2}$	1 per $\frac{1}{8}$ in.

Inspection

After the welding process is decided upon, the operator is qualified, and work in the field is begun, a competent and experienced inspector can usually determine whether a welder is doing satisfactory work by visually examining the deposited metal, listening to the noise of the arc; by watching the splatter; by watching the characteristics of the molten metal being deposited. If there is at any time a question about a weld, it is a simple operation to cut and examine a small section of the welded field seam (Fig. 7). This section or plug can be cut out of the seam with an acetylene torch and the hole can be welded up afterwards. The plug should be sawed through at right angles to the center line of the weld. One half of the plug should then be smoothed with a file, and polished with fine emery cloth. It can then be etched to determine whether or not the welder has made suitable penetration and fusion. The most satisfactory etching medium is a solution of ammonium persulphate. Nitric acid may also be used but this is apt to exaggerate any defects in the cross-section of the weld and not present a true picture; also, nitric acid is a little more dangerous to carry and handle.

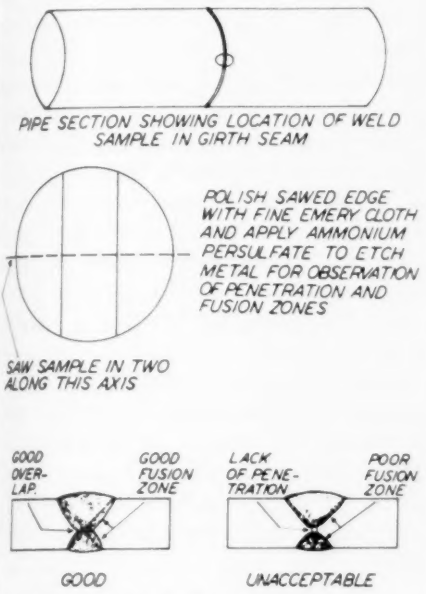
PIPE SECTION SHOWING LOCATION OF WELD SAMPLE IN GIRTH SEAM
POLISH SAWED EDGE WITH FINE EMERY CLOTH AND APPLY AMMONIUM PERSULFATE TO ETCH METAL FOR OBSERVATION OF PENETRATION AND FUSION ZONES
SAW SAMPLE IN TWO ALONG THIS AXIS
GOOD OVER-LAP.
GOOD FUSION ZONE
LACK OF PENE-TRATION
POOR FUSION ZONE
GOOD
UNACCEPTABLE

Fig. 7. Etch Test of Coupons

EXTERNAL VIEW SHOWS NO WELD DEFECTS
PLAN VIEW OF WELD
NOTE BURNT AWAY CORNER
THROAT THICKNESS SHOULD BE 0.4" MEASURES 0.3"
½" PLATE
CROSS SECTION OF WELD COUPON

Fig. 8. Burned Away Corner Fillet Welds

Ammonium persulphate is a crystalline substance and can be carried conveniently in a bottle. When the inspector wishes to etch the cross-section of a weld he can dissolve this crystalline substance in water. The proportions of the solution are not very important and will have very little bearing on the appearance of the etched cross-section. An examination of the

etched cross-section of the weld, either with the eye or with a magnifying glass, will give the inspector a pretty clear picture as to whether or not the weld has completely penetrated the seam, whether or not the metal has been fused sufficiently into the parent metal of the seam, and whether or not the welder has used the proper heat in depositing the metal.

The contour of the completed welds should be checked for convexity and

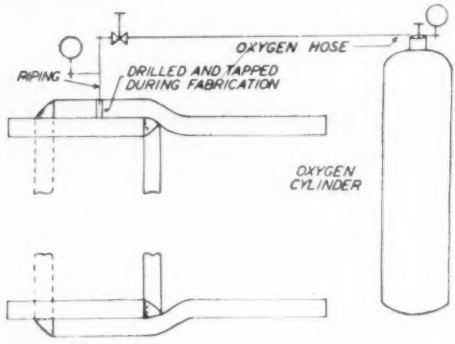

FIG. 9. Method of Testing Tightness of Welded Bell and Spigot Joint; Piping—¼-in. Standard

concavity by "go and no-go" gauges. The A.W.S. in their hand book includes such gauges.

Many times the tops of the bells (Fig. 8) of welded slip joint pipe are burned away due to the carelessness or the inexperience of the welding operator. Externally, the resulting welds might appear satisfactory; actually, the throat thickness is materially reduced. A check on this condition can be made by center punching the pipe around the circumference at 2-ft. intervals, 1 in. back from the top of the bell. By checking from the center punch marks an inspector can tell whether or not the edges have been washed down. A convenient gauge can be easily fabricated by fitting a shoulder against the end of the pipe and locating a hardened steel bushing 1 in. from the shoulder through which center punching can be done. This type of gauge can be slipped quickly around the circumference of the pipe and center punching takes very little time.

It is desirable to check the completed weld. Even a double welded slip joint can be checked. A convenient method of testing the joint is to have the fabricating plant drill and tap a ⅛-in. hole for standard piping in the bell end of the pipe (Fig. 9), and after the field welds have been completed, have men working inside and outside the pipe paint the joint with soapsuds. Then apply a pressure of 100 lbs. of oxygen and if there is any leak the escaping oxygen will form soap bubbles. The leak should be repaired and the test repeated. There is an advantage in this type of test, since immediately after the test has been satisfactorily completed, the pipe can be backfilled with safety.

We believe that if many of the suggestions could be incorporated in a specification for field welding of steel water pipe joints, that the resulting document would not only serve to produce satisfactory work under contract, but would be a guide for work done under force account.

War Problems in Analysis and Treatment

By A. M. Buswell, R. C. Gore, H. E. Hudson Jr., A. C. Wiese and T. E. Larson

SO many good summaries of the properties of war gases have been presented to the technical public in the past months that a fair degree of familiarity with the subject on the part of the reader may be assumed. The authors' purpose here is to present some quantitative data applicable particularly to the possibility of treating water contaminated with these agents.

In this paper are presented condensed discussions of five more or less independent studies of the properties of the two most important war gases—mustard and lewisite—as found in water. The topics presented are: (1) the chlorine demand of mustard and lewisite; (2) a differential titration for the quantitative estimation of mustard and arsenicals, when either or both are present in the same sample; (3) the threshold odor value of mustard and lewisite; (4) a determination of the amount of activated carbon required to remove mustard odors; and (5) experiments in the removal of arsenic.

A paper presented on June 15, 1943, at the Cleveland Conference by A. M. Buswell, Chief, State Water Survey Div., and Prof. of Chemistry, Univ. of Illinois; R. C. Gore, H. E. Hudson Jr. and A. C. Wiese, Special Research Assts., Univ. of Illinois; and T. E. Larson, Chemist, State Water Survey Div., Urbana, Ill.

Chlorine Demand

The primary interests in connection with the possibility of contamination of water supplies with war gases lie in the detection of, and treatment for, the removal of these gases from water. The two most likely and dangerous chemical agents to be encountered are mustard gas and lewisite. The presence of either of these gases or their hydrolyzed products in water produces a chlorine demand. Since a common general method for determining the required treatment of a water for drinking purposes is to measure the chlorine demand, a study of the reaction of chlorine with war gases was carried out.

In both the pilot plant treatment and laboratory analyses, mustard and its hydrolysis product showed a type of break-point phenomenon. Great care must therefore be taken in interpreting chlorine-demand data. As in many analytical reactions, an excess of the reagent must be present so that the reaction for chlorine demand can go to completion. This, together with the fact that mustard is oxidized in two steps, explains the break-point in this case.

The hydrolysis product of mustard gas in water is thiodiglycol. It has a chlorine demand of 2 mols Cl_2 per mol of thiodiglycol.

$$(ClCH_2CH_2)_2S \xrightarrow{H_2O} 2HCl + (HOCH_2CH_2)_2S \xrightarrow{NaOCl}$$

mustard gas → thiodiglycol

$$(HOCH_2CH_2)_2SO \xrightarrow{NaOCl} (HOCH_2CH_2)_2SO_2$$

sulfoxide of thiodiglycol → sulfone of thiodiglycol

Chloramine-T * carries the reaction only to sulfoxide in 5 min. at pH 7.

previously been destroyed and a 5-min. contact time was allowed before addition of KI for the thiosulfate titration. The data are shown in Fig. 1. It should be noted that a residual chlorine was present, often as high as 5 ppm., even when the chlorine demand was not satisfied.

Tap water containing 100 ppm. re-

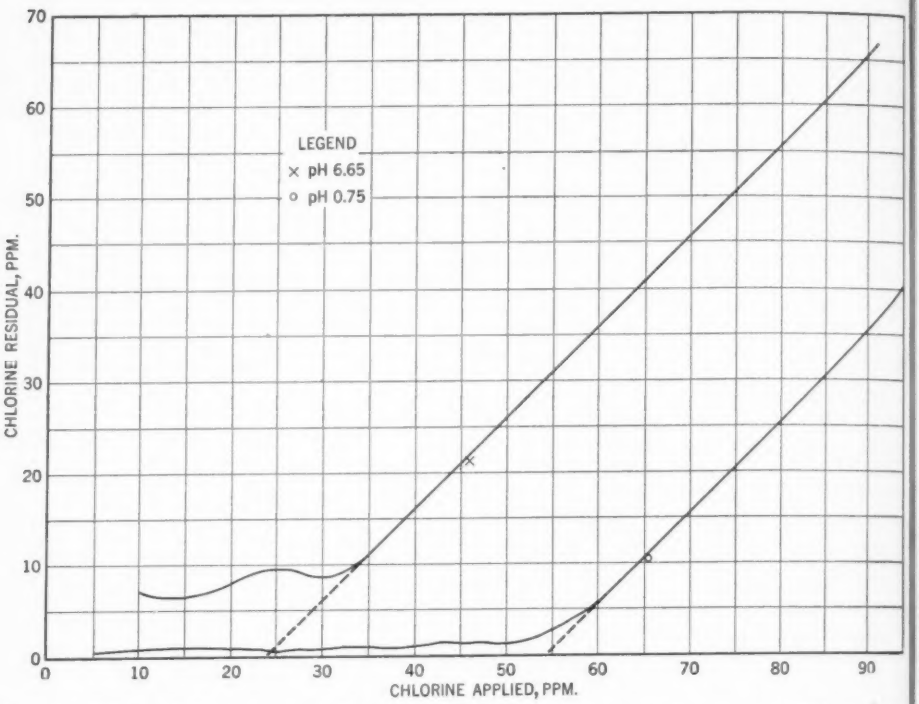

FIG. 1. Effect of Treatment of Tap Water Containing 49 ppm. Commercial Thiodiglycol With Chloramine-T; 5-min. contact; chlorine by thiosulfate

Experimental: Tap water containing 49 ppm. commercial thiodiglycol was treated with varying quantities of chlorine as Chloramine-T. Nitrites had distilled commercial thiodiglycol was treated with varying quantities of chlorine (as HTH) at pH 1. A 15-min. contact time was allowed before addition of KI. Part of the data were obtained with a 60-min. contact time before addition of KI. The residual chlorine is shown in Fig. 2. Again it is to be noted that a residual chlorine was present although the chlorine demand was not satisfied.

* Chloramine-T is sodium salt of paratoluene-sulfonchloramide, a product of the Monsanto Chemical Co., St. Louis. The material is distributed by Merck & Co., Inc., Heyden Chemical Corp. and E. R. Squibb & Sons. It may be obtained in both tablet and powder forms through retail drug stores.

Similarly tap water containing hydrolyzed mustard in a concentration sufficient to produce a 189 ppm. chlorine demand was treated with varying quantities of chlorine (as HTH) at pH 7. After 5 min., samples were removed and chlorine determined by ortho-tolidine. As was expected, the residual chlorine was again present at below break-point doses (Fig. 3), although not in so great a concentration as would be expected if the residual chlorine were determined by the starch-iodide titration.

These data indicate that the residual chlorine obtained on treatment of a solution of thiodiglycol (or mustard gas) is not a function of the amount of chlorine added until the break-point has been exceeded to an appreciable extent. In other words, the chlorine demand for a given time of contact is a function of the chlorine added to considerably beyond the break-point.

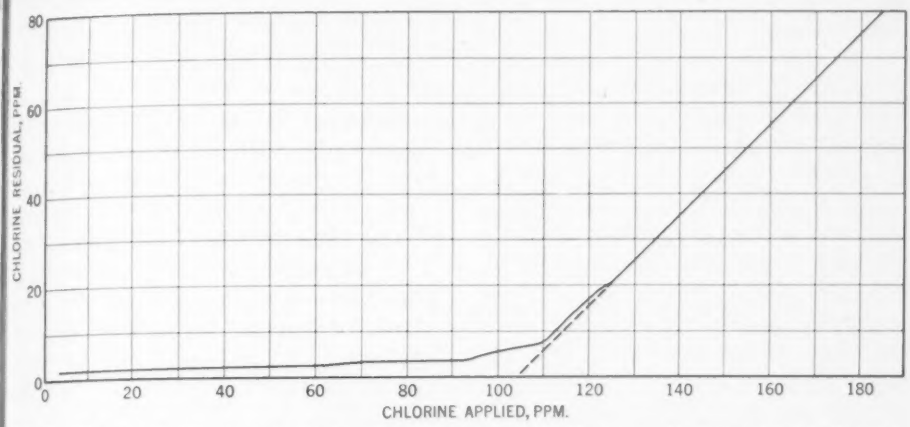

FIG. 2. Effect of Treatment of Tap Water Containing 100 ppm. Redistilled Thiodiglycol With Calcium Hypochlorite at pH 1; 15-min. contact; chlorine by thiosulfate

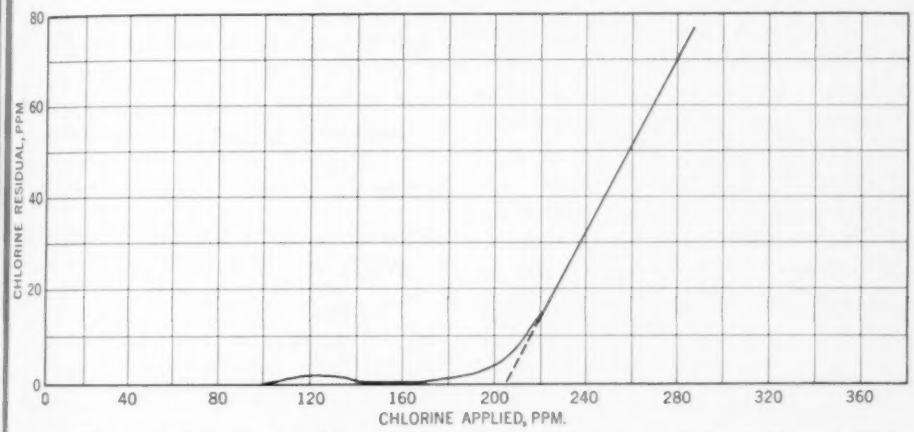

FIG. 3. Effect of Treatment of Tap Water Containing 200 ppm. Hydrolysed Mustard With Calcium Hypochlorite at pH 7; 5-min. contact; chlorine by ortho-tolidine

Differential Titration

It will be noted from Fig. 1 that the chlorine demand determined with Chloramine-T at pH 7 is only half that at pH 1 or with HTH. This observation led to the development of the following procedure as a quantitative differential method.

The chlorine demand is determined by adding Chloramine-T to the water and then titrating the excess by iodometry. Chloramine-T was selected as the chlorinating agent because it is stable and its oxidation potential varies with pH so that a differential chlorine demand titration is possible. It was found that, for a 5-min. reaction time, 2 mols of chlorine "react with 1 mol of thiodiglycol (or HS*) at pH 1.0," while the reaction is mol for mol at pH 6 to 7 and no reaction occurs at pH 10.5 or above. With the arsenical agents (lewisite) the reaction is mol for mol over the entire pH range.

The presence of nitrite in the water was the main interference encountered. Nitrites catalyze the oxidation of iodides to iodine by oxygen in acid solution and thus cause the estimation of the residual chlorine to be high. The interference was overcome by the addition of sulfamic acid which destroys the nitrites. The procedure for the chlorine demand determination is as follows:

Determination of Chlorine Demand in Absence of Nitrites

Chlorine Demand at pH 1: To 100 ml. of water add 5 ml. concentrated hydrochloric acid and 25 ml. 0.03 *N* Chloramine-T solution and allow to react for 5 min. Add 1 g. potassium iodide and allow to stand for 3 min. Dilute with 100 ml. distilled water and titrate with 0.03 *N* sodium thiosulfate to a faint yellow color. Add 1 ml. starch solution and continue the titration to the disappearance of the blue color. The chlorine demand, in parts per million, equals 355 (25 × normality of Chloramine-T — ml. titration × normality of thiosulfate).

Chlorine Demand at pH 6–7: Adjust the pH of 100 ml. of water to from 6 to 7 by means of 6 *N* hydrochloric acid. Add 25 ml. 0.03 *N* Chloramine-T and allow to react for 5 min. Add 1 g. potassium iodide, 1 ml. concentrated hydrochloric acid and allow to stand for 3 min. Dilute with 100 ml. distilled water and carry out the titration as above. The calculations are the same as above.

Chlorine Demand at pH 10.5: Adjust the pH of 100 ml. of water to 10.5 by the addition of sodium hydroxide. Add 25 ml. 0.03 *N* Chloramine-T and allow to react for 5 min. Add 1 g. potassium iodide and 2 ml. concentrated hydrochloric acid and allow to stand for 3 min. Titrate as before and calculate the chlorine demand as above.

Determination of Chlorine Demand in Presence of Nitrites

Chlorine Demand at pH 1: To 100 ml. of water add 5 ml. concentrated hydrochloric acid, 2 ml. 1-per cent sulfamic acid solution and allow to stand for 10 min. Then add 25 ml. 0.03 *N* Chloramine-T and proceed with the chlorine demand determination as previously described.

Chlorine Demand at pH 6–7: Acidify 100 ml. of water with 4 or 5 drops of 6 *N* hydrochloric acid, add 2 ml. 1-per cent sulfamic acid and allow to stand for 10 min. Add 5 ml. phosphate buffer (this will adjust the pH

* The following Chemical Warfare Service symbols have been used throughout the paper: HS—mustard gas; M-1—lewisite; ED—ethyldichlorarsine; MD—methyldichlorarsine.

to about 6.5) and proceed with the chlorine-demand determination as before.

Chlorine Demand at pH 10.5: Acidify 100 ml. of water with 4 or 5 drops of 6 *N* hydrochloric acid, add 2 ml. 1-per cent sulfamic acid solution and allow to stand for 10 min. Add 2 or 3 pellets of sodium hydroxide to adjust the pH to 10.5 and carry out the procedure for chlorine demand as before.

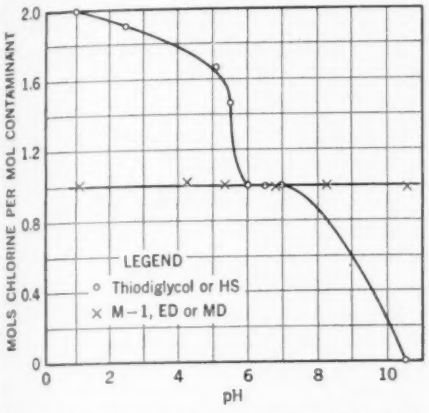

FIG. 4. Reaction of HS and Arsenicals With Chloramine-T and Variation With pH

Interpretation of Data

The chlorine demand at pH 1.0 equals the amount of HS (ppm.) plus the arsenical demand as arsenic (ppm.). The chlorine demand at pH 6 to 7 equals half the amount of HS (ppm.) plus the arsenical demand as arsenic (ppm.). The demand at pH 10.5 equals the arsenical demand as arsenic (ppm.). Figure 4 gives sample curves upon which these calculations are based. This interpretation of data is only an approximation, but it is nearly correct because of coincidences in equivalent weights.

The following conditions must be carefully controlled when running the determination:

1. pH must be adjusted properly.
2. Reaction time must be carefully controlled.
3. An excess of 10 ppm. Chloramine-T must be present.
4. The Chloramine-T stock solution should be standardized whenever used.

Threshold Odors

For the contamination of water supplies, a number of materials which possess very strong odor production characteristics may be used. Work has been done on the measurement of the odors produced by some of these materials and on the measurement of the treated water quality resulting from various processes for odor removal.

All odor tests were made by the water dilution method, using odor-free water. Samples were smelled with the aid of a nosepiece. The tests were made at 65°C. and 100-mm. portions were used.

Table 1 gives the results of some measurements on the odors produced

TABLE 1

Odor Threshold Values

Material	Character of Odor	Threshold Concn.*
		ppb.
Chlorine	Chlorinous	70
Dioxane		300
Sulfur monochloride	Sulfurous	400
Mustard disulfide ($ClCH_2CH_2SSCH_2CH_2Cl$)	Onions	130
Mustard disulfide (from mustard)	Onions	0.8
Dithian	Mustard gas	280
Levinstein mustard	"	15–50
Thiodiglycol mustard	"	170
Commercial thiodiglycol (Kromfax)	Sweetish, alcholic	14,000†
Thiodiglycol, redistilled	Aromatic	14,000†

* *See* footnote p. 1308.

† Approx., actual values probably lower.

by certain compounds in water. The substances reported were chosen because they were known constituents of various grades of "mustard." Chlorine is included for comparison and dioxane for blank corrections. The threshold concentration of lewisite was found to be between 100 and 300 parts per billion (ppb.).*

The principal material present in water solutions of mustard is the hydrolyzed product of the mustard—thiodiglycol. From the table, it is seen that the odor produced by thiodiglycol is far less perceptible than that attributed to Levinstein mustard. The Levinstein mustard also has a lower threshold concentration than that of the pure mustard made from redistilled thiodiglycol. Mustard disulfide obtained from Levinstein mustard had the lowest threshold concentration of any of the materials tried. Attention is directed to the fact that this material had a threshold concentration of less than 1 ppb., which places it ahead of chlorophenol for odor production in water.

These data are cited to indicate that in some cases the problem of removal of contaminants may be complicated by odor removal problems. Hydrolyzed mustard is not toxic, but, due to the odors formed, water contaminated with it in any appreciable concentration is likely to be unfit to drink.

* The *threshold concentration*, stated here in parts per billion, refers to the smallest concentration of odor-producing material in water required to give a perceptible odor. The threshold concentration should not be confused with the *threshold number*, which is the ratio of the total diluted volume at which odor is barely perceptible to the volume of sample used in dilution. If the *threshold concentration* is known, that value multiplied by the *threshold number* will give the concentration of odor-producing material in the sample.

Treatment of Mustard With Powdered Activated Carbon

Experimental work on the treatment of water containing Levinstein mustard was carried on in a pilot water treatment plant. To a sedimentation tank filled with tap water was added a weighed quantity of mustard. This material was mixed at least 15 min. In some of the tests, a 10-min. period of chlorination was then used. For all the tests, activated carbon slurry was then added and given 15 min. mixing, after which the coagulant solution was added and 5 min. additional mixing applied. The water was then permitted to stand quietly for 30 min., after which the settled water was taken to the two rapid sand filters through a float-operated decanting outlet.

Rates of filtration and losses of head were carefully controlled. One filter was operated at 2 gpm. per sq.ft., the other at a considerably higher rate. The only difference in results between these two filters was in the turbidity of the filtered water, which was higher in the unit operated at the high filtration rate.

The results of these tests are summarized in Fig. 5. Ferric sulfate (Ferrisul) was the coagulant employed in all but two runs. The powdered carbon used was "Hydrodarco."

Runs No. 13, 14 and 20 made use of chlorine in addition to the treatment mentioned above, hence the data must be interpreted separately. The results of these experiments were plotted with the removal of chlorine demand and odor per part per million carbon against the residual concentration of the material being adsorbed. It was readily seen that when the final chlorine demand of water containing mustard was reduced to a value of 5 ppm., the removal ratio was approximately 0.01

(Fig. 5). It was necessary to use 100 lb. of activated carbon per pound of chlorine demand to be removed.

A similar plotting of odor removal was made. The results of these experiments indicated approximately that, in order to reduce the threshold number of the treated water to 20, about 1 part of carbon will be required per threshold number in the raw water.

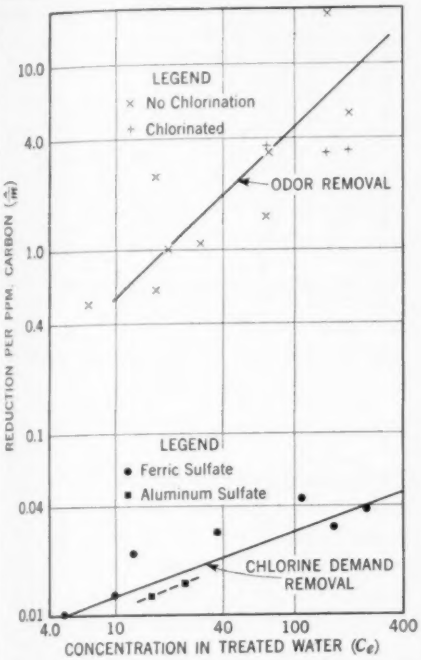

FIG. 5. Treatment of Levinstein Mustard With Powdered Activated Carbon—logarithmic plotting.

Data cited elsewhere in this paper indicate that the predominating odor present in water contaminated with mustard was due to a component other than the pure mustard. Whereas the threshold concentration of the mustard is approximately 15 ppb., the calculated threshold concentrations of the contaminant remaining in the treated waters (expressed as ppb. chlorine demand) range from 200 to 2000 ppb. These values approach more nearly the threshold concentration of thiodiglycol, which was found to be approximately 14 ppm. It therefore appears that the carbon treatment is more effective in adsorbing the most odorous portions of the Levinstein mustard than in the absorption of the thiodiglycol. This is also indicated by comparison of the slopes of the curves in Fig. 5.

The use of chlorination to eliminate chlorine demand did not appear to assist in the odor removal.

Some preliminary work on treatment of water contaminated by lewisite indicated that its odor was removed more readily by powdered activated carbon than was the odor of mustard.

Removal of Arsenic by Coagulation

Some experimental work has been carried on in the removal of inorganic arsenic in water by coagulation. Laboratory jar tests on its removal indicated that some reduction of arsenic is obtained when the coagulant is filter alum and when the pH is controlled rather carefully between 6.0 and 7.0.

The following data were obtained from the treatment of water to which 25 ppm. sodium arsenate was added. Removals as great as 60 per cent were obtained with ferric sulfate (Ferrisul) when 5 gpg. was used at a pH of 5.2. When 10 gpg. ferric sulfate (Ferrisul) was added, the arsenic content was reduced to less than 1 ppm. at pH values below 6.

A number of plant runs were made in the experimental water treatment plant using water contaminated with sodium arsenate and sodium arsenite. In the experimental plant, two processes comparable to municipal treatment were employed, one using the precipitator and the other a more con-

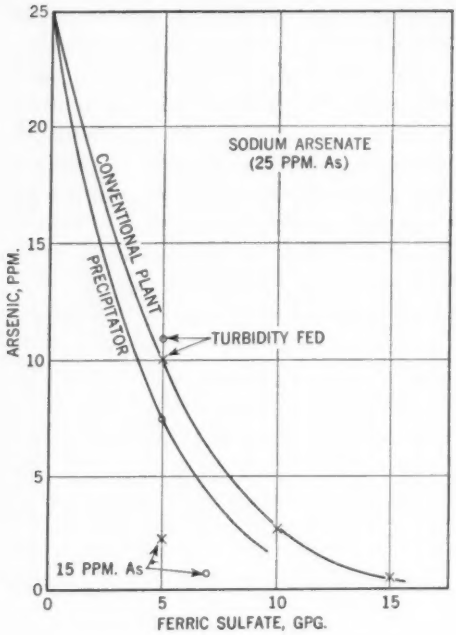

FIG. 6. Removal of Sodium Arsenate

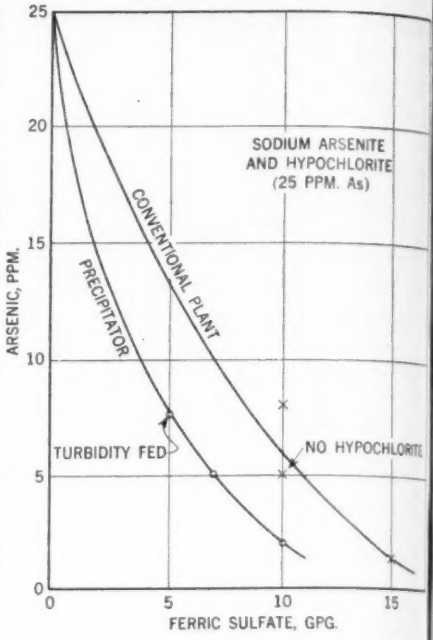

FIG. 7. Removal of Chlorinated Sodium Arsenite

TABLE 2

Treatment of Levinstein Mustard With Powdered Activated Carbon

Run No.	Nominal HS Feed	Carbon Feed	Chlorine Demand				Odor Threshold		
			Raw	Treated	Reduction	$\frac{x}{m}$ *	Raw	Treated	$\frac{x}{m}$ *
	ppm.	*ppm.*							
1	—	875	31.8	12.5	19.3	0.022	1,000	30	1.
2	100	3000	43.7	9.8	37.5	0.013	3,000†	20	1.
3	25	750	15.0	9.0	6.0	0.0087	500	17	0.
7	200	2000	95.5	36.2	59.3	0.0296	5,000	17	2.
8	400	500	183	168	15.5	0.0310	10,000	150	20
9	25	1500	20.0	5.0	15.0	0.010	800	7	0.
10	800	3000	365	247	118	0.0393	30,000	150	10
13‡	200	2000	128	5.0	—	—	7,000	200	3.
14‡	200	2000	126	1.5	—	—	7,000	150	3.
18§	100	2000	56.0	24.2	31.8	0.0159	3,000	70	1.
19§	100	3000	54.3	16.0	38.3	0.0128	4,000	70	3.
20	200	2000	93.0	24.0	—	—	7,000	70	3.

* Quantity contaminant removed per unit carbon used.
† Denotes estimate.
‡ Chlorination used for Runs 13 and 14.
§ Aluminum sulfate.

ventional mixing, sedimentation and filtration treatment. The rate of flow through each of these two units was 1 gpm. The precipitator, when operated at this rate, had a 2-hr. detention period. For the conventional unit, mixing time was 45 min. and settling time 3 hr. Water from the conventional unit was filtered at 2 gpm. per sq.ft., while the water from the precipitator was filtered at a somewhat lower rate.

The results of the arsenic removal tests for both units are summarized in Figs. 6 and 7. Fig. 6 indicates that it is possible to reduce arsenic content of 25 ppm. to 5 ppm. or less with not more than 8 gpg. ferric sulfate. The filtered water from the precipitator unit appeared to contain approximately 2 ppm. less arsenic than the filtered water from the conventional type plant, when a similar coagulant dose was employed. Attention is called to the fact that the data on arsenate removal through the precipitator unit are meager.

Figure 7 shows the arsenic remaining in the water when sodium arsenite was the contaminant and various ferric sulfate (Ferrisul) dosages were employed. Calcium hypochlorite was added to oxidize the arsenite to arsenate. These data showed that it was possible to reduce 25 ppm. arsenic of oxidized sodium arsenite to 5 ppm. or less with a coagulant dose not exceeding 12 gpg. The residual arsenic in the filtered water was approximately 4 ppm. lower in the effluent from the precipitator unit than in the finished water from the conventional plant.

In all instances nearly all of the arsenic present in the settled water passed through the filters.

Tables for the Determination of Alkaline Compounds in a Softened Water

By Douglas Feben

THE student learning the chemistry of water treatment and analysis is taught that the alkalinity of a natural water is mainly represented by the concentration of carbonates, bicarbonates and hydroxides. He then proceeds to discover that these can be determined by titration with standard acid to two predetermined pH values with indicators selected to show color changes at these points; the indicators commonly used are methyl-orange and phenolphthalein. He further learns that the former indicator measures all the alkalinity and the latter all the hydroxides together with one-half the normal carbonates. Armed with this information, he is able, by algebraic processes, to make an analysis of the various forms of alkalinity from these two simple titrations. Finally, he is introduced to a table such as that on page 66 of *Standard Methods*,* wherein the algebraic relationships of these two titrations are all worked out for every possible combination.

On entering the field as a water treatment plant operator or analyst, the average student finds that he is a busy person with little time to recall and work out these various combinations every time he makes determinations of alkalinity, so he proceeds to use the aforementioned convenient table exclusively. But if the water treatment includes softening, he frequently finds it desirable to make a rapid analysis of the specific alkaline compounds present and resultant from the partial or complete softening processes. The literature provides lengthy discussions and many rules for securing these results, but the use of tables, similar to that given in *Standard Methods,* would greatly facilitate the computation of such an analysis. The writer therefore submits the following tables for this purpose.

Table 1 is identical with that given in *Standard Methods,* giving the alkalinity due to hydroxides, carbonates and bicarbonates from a comparison of the methyl-orange and phenolphthalein titrations.

Table 2 gives the soda-alkalinity (negative non-carbonate hardness), non-carbonate hardness and carbonate hardness from a comparison of the methyl-orange alkalinity with the total hardness, the latter being determined by a simple titration with standard soap solution, or preferably with soda reagent.

A contribution by Douglas Feben, Sr. San. Chemist, Dept. of Water Supply, Detroit.

* *Standard Methods for the Examination of Water and Sewage.* Am. Pub. Health Assn. & Am. Water Works Assn., New York (8th ed., 1936).

In Table 3, the caustic alkalinity (hydroxides), as determined from Table 1, is compared with the soda-alkalinity, as determined from Table 2. This comparison gives estimations of sodium hydroxide, sodium carbonate, normal carbonates of calcium and magnesium and calcium hydroxide.

Key to Tables 1, 2 and 3—Values Expressed in Terms of $CaCO_3$

			Abbreviations
Determined directly by titration		Alkalinity to phenolphthalein	P
		Alkalinity to methyl-orange	M
		Total hardness	T.H.
Determined indirectly by calculation from above	From Table 1	Caustic alkalinity	OH
		Normal carbonate alkalinity	CO_3
		Bicarbonate alkalinity	HCO_3
	From Table 2	Soda alkalinity	NaAlky.
		Non-carbonate hardness	Non-CO_3 hardness
		Carbonate hardness	CO_3 hardness
	From Table 3	Sodium hydroxide	NaOH
		Sodium carbonate	Na_2CO_3
		Normal carbonates of Ca and Mg	Ca and $MgCO_3$
		Calcium hydroxide	$Ca(OH)_2$

TABLE 1

Comparison of Phenolphthalein and Methyl-Orange Alkalinities

	OH	CO_3	HCO_3
When P = zero	0	0	M
" P < ½M	0	2P	(M − 2P)
" P = ½M	0	2P	0
" P > ½M	(2P − M)	2(M − P)	0
" P = M	M	0	0

TABLE 2

Comparison of Total Hardness and Methyl-Orange Alkalinity

	Na Alk.	Non-CO_3 hardness	CO_3 hardness
When T.H. < M	(M − T.H.)	0	T.H.
" T.H. = M	0	0	T.H.
" T.H. > M	0	(T.H. − M)	M

TABLE 3

Comparison of Caustic and Soda Alkalinities

	NaOH	Na_2CO_3	Ca & $MgCO_3$	$Ca(OH)_2$
When OH < Na Alky.	OH	(Na Alky. − OH)	T.H.	0
" OH = Na Alky.	OH	0	CO_3	0
" OH > Na Alky.	Na Alky.	0	CO_3	(OH − Na Alky.)

Two examples from *Water Supply and Treatment* * may serve to show how the tables are used:

			Ex. 1 ppm.	Ex. 2 ppm.
Determined directly by titration		Methyl-orange alkalinity	70	60
		Phenolphthalein alkalinity	40	40
		Total hardness	105	35
Determined indirectly by calculation from above	From Table 1	Caustic alkalinity	10	20
		Normal carbonate alkalinity	60	40
		Bicarbonate alkalinity	0	0
	From Table 2	Soda alkalinity	0	25
		Non-carbonate hardness	35	0
		Carbonate hardness	70	35
	From Table 3	Sodium hydroxide	0	20
		Sodium carbonate	0	5
		Normal carbonate of Ca and Mg	60	35
		Calcium hydroxide	10	0

In Example 1, it can be observed that the phenolphthalein alkalinity is greater than half the methyl-orange alkalinity, which means that Line 4 of Table 1 is used. This shows that the caustic alkalinity is equal to (2P — M) or 10 ppm.; the normal carbonate alkalinity is equal to 2(M — P) or 60 ppm.; and no bicarbonates are present since they are incompatible with caustic alkalinity.

The next step is to observe that the total hardness is greater than the methyl-orange alkalinity, which means that Line 3 of Table 2 is used. This shows that there is no soda alkalinity present; the non-carbonate hardness is equal to (T.H. — M) or 35 ppm.; and the carbonate hardness is represented by the methyl-orange alkalinity, or 70 ppm.

The next step is to observe that the caustic alkalinity (10 ppm.) is greater than the soda alkalinity (0), which means that Line 3 of Table 3 is used. This shows that sodium hydroxide, if present, is represented by the soda alkalinity, which in this case is zero; sodium carbonate is absent; normal carbonates of calcium and magnesium are represented by the normal carbonate alkalinity, 60 ppm.; and calcium hydroxide is equal to (OH — NaAlky), or 10 ppm.

In Example 2, it is observed that the phenolphthalein alkalinity is again greater than half the methyl-orange alkalinity, so that Line 4 of Table 1 should again be used for the determination of caustic, carbonate and bicarbonate alkalinity.

It will be observed, however, that in this case, the total hardness is less than the methyl-orange alkalinity, so that Line 1 of Table 2 should be used for the determination of soda alkalinity and carbonate hardness.

Finally, it will be observed that the caustic alkalinity is less than the soda alkalinity, so that Line 1 of Table 3 should be used for the final estimations of specific alkaline compounds.

* HOOVER, CHARLES P. Water Supply and Treatment. Natl. Lime Assn., Washington, D.C. (2nd ed., 1936).

Control of Chlorination

Committee Report

Introduction

THE methods of procedure recommended in the following report of the Committee on Control of Chlorination are those which the committee believes are best suited at this time to control chlorination. Methods are presented for the determination of chlorine, to differentiate between chlorine and chloramine, to measure both high and low residuals in the field as well as in the laboratory and to determine chlorine demand under any condition which may be specified.

All this information was put into one report because the methods are not necessarily alternate ones, each having its place under certain conditions. In the eighth edition of *Standard Methods for the Examination of Water and Sewage*, one method is given as official and other methods are published in the Appendix. The members of this committee feel that this causes some confusion in the minds of analysts, particularly those in small plants, and believe that it is preferable to have all accredited methods grouped together.

Methods for the determination of available chlorine or chloramine are necessarily based upon reactions with reducing agents that are not specific for these materials. Definite test conditions under which such specificity is attained in the presence of particular interfering oxidizing agents have been described by a number of investigators, and the results they obtained have been considered in formulating this report. Technics deemed suitable for consideration as standard methods of the American Public Health Association and the American Water Works Association have been described. The committee has endeavored to give references to the literature for every important step in the methods discussed.

The purity of ortho-tolidine, as purchased on the market, has always been a matter of concern. Chamberlin found that even though the salt melted at 129°C., it still might contain considerable impurities. He found also that the dihydrochloride, as sold on the open market, is very much purer than the ortho-tolidine. This salt has an advantage in being soluble in water and

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Committee personnel includes: H. A. Faber, Douglas Feben, H. H. Gerstein, F. W. Gilcreas, A. E. Griffin, H. O. Hartung, P. C. Laux, W. L. Mallmann and R. D. Scott.

This report has been approved by the Executive Committee of the Water Purification Division, the Committee on Water Works Practice and Board of Directors of the A.W.W.A.

makes possible a test for free chlorine which is not yet sufficiently developed to include in *Standard Methods.*

The concentration of the acid in the ortho-tolidine reagent is increased so that it will produce a suitable pH in the sample under examination even if the sample has up to 1000 ppm. alkalinity. The amount of acid is less than that used in sewage plant laboratories for the reason that the ortho-tolidine reagent in field kits may be subjected to low temperatures in winter. Higher concentrations of acid raise the temperature at which ortho-tolidine goes out of solution and it is brought back into solution with some difficulty. To insure a pH of 1.3 or lower and a ratio of ortho-tolidine to chlorine of at least 3:1 whenever the two are in contact, it is specified that the reagent be placed in the cell, tube or comparison bottle first and the sample added to it.

The six-month time limit for replacement of ortho-tolidine reagent was fixed arbitrarily as a precaution against the effect of possible occasional exposure to high temperatures or direct sunlight, resulting in discoloration or precipitation. The caution against contact with rubber is based on observations, not reported in the literature, that significant amounts of reducing substances are extracted from some types of rubber medicine bottle closures by ortho-tolidine reagent, particularly that containing more than 15 per cent acid.

The reaction time and the temperature specified were selected to permit measurement of a maximum proportion of the chloramines present, while minimizing loss of color by fading or increase of color due to interfering oxidizing agents which react slowly with ortho-tolidine (nitrites, oxidized iron and compounds formed by chlorine with organic matter).

The method given for preparation of zero-chlorine-demand water was selected for convenience; although ammonia-free water was not required, the preference expressed for it is based on difficulties encountered in removing large amounts of ammonia with chlorine alone. Due to the rapidity with which this water may absorb some laboratory fumes, it should be examined for nitrite, chlorine or reducing agents immediately before use for special investigations dealing with very low concentrations of chlorine.

The Scott chromate-dichromate standards provide better color matches with ortho-tolidine-chlorine color than do standards containing copper sulfate. The modified Scott permanent chlorine standards recommended by the committee for use with ortho-tolidine are based on the work done primarily by Chamberlin and Glass. Their choice of buffer and handling of that buffer solution are the result of spectrophotometric work done within the past year. The new standards produce good visual matches and almost exact spectrophotometric matches when the chlorine solution is at pH 1.3 and the ortho-tolidine : chlorine ratio at least 3:1. The phosphate buffers are specified even though some difficulty has been had with them in the past due to precipitates. Clark * states that the precipitate is probably due to aluminum present as an impurity in the phosphate. By allowing time, initially, for the precipitate to form and be filtered out, standards have lasted for several months. There is also a possibility

* CLARK, W. MANSFIELD. *The Determination of Hydrogen Ions.* Williams & Wilkins Co., New York (3rd ed., 1928).

that bacterial action may form precipitates. The borate buffers are not sufficiently heavy to maintain the proper pH with certainty and, up to the present, there is nothing to take the place of the phosphate buffers.

The committee is making a departure from precedent in its recommendation that commercially prepared permanent ortho-tolidine-chlorine standards be used in preference to those prepared in individual laboratories. In the past few years there has been a great improvement in their accuracy. Checking permanent standards with temporary standards is a task that is very difficult even for experienced analysts to perform. In the great majority of laboratories there is no employee competent to do the work. It is felt by the committee that very much greater uniformity of results will be attained by the use of commercially prepared permanent standards.

The iodometric method is brought back as a standard because it is the basis for the standardization of chlorine water used in preparing temporary standards. Also, it is more suitable for determining high chlorine residuals, which are now more frequently encountered than heretofore since they generally result from break-point chlorination. Suitably handled, this method minimizes interference by certain compounds frequently present in water. Acetic acid is specified, with sulfuric acid as an alternate. Hydrochloric acid is to be avoided because some lots of it liberate iodine from potassium iodide.

The ortho-tolidine flash test, Part C, is a qualitative technic for chlorine uncombined with ammonia, amines or organic matter and is unaffected by the slow-acting interfering agents, nitrites or oxidized iron, but is affected by colloidal manganese dioxide.

The chlorine demand method presented is designed to lend itself to the determination of the so-called immediate demand or to any other demand using longer contact time or larger chlorine dosages. It can be used, for instance, in the determination of the break-point. It specifies that chlorine water be used as the source of chlorine when liquid chlorine is used in operation. The alternate use of "Zonite" as the source of chlorine, given in Part F, is more convenient for use in the field or when facilities are not available for standardizing chlorine water. Generally speaking, it would appear that results with "Zonite" will be of the same order of accuracy as with chlorine water. It is suitable for use on either water or sewage.

The committee will be glad to have referred to it any criticism or difficulties that may be brought out in the use of the procedures presented.

Report of the Committee

The methods presented herein are designed to measure the amount of chlorine, to indicate whether the chlorine is free or combined with ammonia and to provide means for determining the desired treatment.

The methods outlined in this report are intended to be used on: (a) polluted water, (b) water in process of purification, (c) at the end of the purification process, (d) incidental to the distribution of water prepared for human consumption, (e) on swimming pool water, (f) on condenser water and (g) on industrial process water.

Part A—Ortho-tolidine Method

When ortho-tolidine is used to measure chlorine the analyst must satisfy himself as to the presence and the amount of interfering substances in the sample to be tested. Such substances include nitrites (1), ferric compounds (2), manganic compounds (3, 4) and, possibly, organic iron compounds (5), lignocellulose (5) and algae (5). The effect of these substances is to increase the apparent chlorine content of the sample under examination. Suspended matter interferes and should be removed by centrifuging prior to test or, if the turbidity is not too high, a compensating colorimeter, which also corrects for existing color (6, p. 83) and turbidity in the sample, may be used.

In chlorinated water containing less than 0.3 ppm. iron, 0.01 ppm. manganic manganese and/or 0.10 ppm. of nitrite nitrogen, the development of the characteristic yellow color with ortho-tolidine may be accepted as being due to chlorine.

If iron and manganese are present in the above amounts, the starch-iodide method is preferable (7), although it also is subject to interference if handled improperly. If nitrite is present in an interfering amount, the provision that the color development with ortho-tolidine be carried on in total darkness (1) almost entirely eliminates such interference. It should be noted that significant amounts of nitrite will not exist in water containing free chlorine, but may exist in the presence of chloramine (1).

This method measures both the free chlorine and that combined with nitrogenous compounds. If it is desired to determine whether the chlorine is present in free or combined form, the "flash test" (Part C) (8) may be used.

Recent work has shown that, to obtain the correct color development with chlorine and ortho-tolidine up to 10 ppm., (a) the solution must be at pH 1.3 or lower during the contact period (9, 10) and (b) the ratio of ortho-tolidine to chlorine (both by weight) must be at least 3:1 (9, 11).

Sec. 1—Reagents

1.1. *Ortho-tolidine Reagent—Method 1* (12): Dissolve 1.35 g. ortho-tolidine dihydrochloride in 500 ml. distilled water. Add this solution, with constant stirring, to 500 ml. dilute hydrochloric acid made by mixing 350 ml. distilled water and 150 ml. concentrated hydrochloric acid (sp.gr. 1.18–1.19).

1.1.1. If it is necessary to use ortho-tolidine, this reagent should be obtained in the purest possible condition. Even so, ortho-tolidine contains more impurities than the ortho-tolidine dihydrochloride and is therefore less satisfactory (12).

1.2. *Ortho-tolidine Reagent—Method 2* (9): Grind 1 g. ortho-tolidine in a mortar with 5 ml. dilute hydrochloric acid, made by adding 150 ml. concentrated hydrochloric acid (sp.gr. 1.18-1.19) to 350 ml. distilled water.

1.2.1. Add 150–200 ml. of distilled water. The ortho-tolidine goes into solution immediately.

1.2.2. Transfer the solution to a 1.0-liter graduate and add the balance (495 ml.) of the dilute acid (Sec. A–1.2) and make up to 1.0 liter with distilled water.

1.3. *Storage of Ortho-tolidine Solution:* The ortho-tolidine solution should be: (a) stored in amber bottles or in the dark (13), (b) protected at all times from direct sunlight (13), (c) used no longer than six months, (d)

kept from contact with rubber and (e) maintained at normal temperatures. At temperatures less than 0°C., the ortho-tolidine will precipitate from solution and cannot be redissolved easily. The use of the reagent from which part of the ortho-tolidine has precipitated may lead to errors due to a deficiency of ortho-tolidine.

Sec. 2—Permanent Chlorine Standards (12)

2.1. *0.5* M *Phosphate Buffer Solution:* Allow a sufficient quantity of disodium hydrogen orthophosphate dodecahydrate ($Na_2HPO_4 \cdot 12H_2O$) to dry over a saturated solution of potassium carbonate ($K_2CO_3 \cdot 2H_2O$) until the weight remains constant for one week and weigh as $Na_2HPO_4 \cdot 2H_2O$ (14, p. 123). If disodium hydrogen orthophosphate anhydrate (Na_2HPO_4) is used, dry at 110°C. and cool in a desiccator.

Dissolve 28.66 g. disodium hydrogen orthophosphate dihydrate ($Na_2HPO_4 \cdot 2H_2O$) (or 22.86 g. Na_2HPO_4) and 46.14 g. potassium dihydrogen orthophosphate anhydrate (KH_2PO_4) in 1.0 liter distilled water. Allow to stand for at least several days before using, to allow time for formation of any precipitate which must be filtered out prior to use.

2.2. *0.1* M *Phosphate Buffer Solutions (pH = 6.45):* Filter solution as prepared in Sec. A–2.1 and dilute 200 ml. to 1.0 liter with distilled water.

2.3. *Strong Chromate-Dichromate Solution:* Dissolve 1.55 g. potassium dichromate ($K_2Cr_2O_7$) and 4.65 g. potassium chromate (K_2CrO_4) in 0.1 *M* phosphate buffer (Sec. A–2.2) and dilute to 1.0 liter with the 0.1 *M* phosphate buffer. This solution represents 10.0 ppm. chlorine when viewed through a 240–300-mm. depth.

2.4. *Dilute Chromate-Dichromate Solution:* Dissolve 0.155 g. potassium dichromate ($K_2Cr_2O_7$) and 0.465 g. potassium chromate (K_2CrO_4) in 0.1 *M* phosphate buffer (Sec. A–2.2) and dilute to 1.0 liter with the 0.1 *M* phosphate buffer. This solution may also be prepared by diluting 100 ml. strong chromate-dichromate solution (Sec. A–2.3) to 1.0 liter with 0.1 *M* phosphate buffer. This solution represents 1.0 ppm. chlorine when viewed through all cell depths.

2.5. *Modified Scott Permanent Chlorine Standards (0.01–1.0 ppm.)* (15, p. 233): The volumes of dilute chromate-dichromate solution (Sec. A–2.4) indicated in Table 1 are pipetted into 100-ml. tubes of any uniform length and diameter or into 100-ml. volumetric flasks for use in bottles. The volume is then made up to the 100-ml. mark with 0.1 *M* phosphate buffer solution (Sec. A–2.2). These standards can be read at any cell depth up to 300 mm.

TABLE 1

*Chlorine Standards—Modified Scott Formula—0.01–1.0 ppm.**

Chlorine	Chromate-Dichromate Soln.†	Chlorine	Chromate-Dichromate Soln.†
ppm.	*ml.*	*ppm.*	*ml.*
0.01	1	0.35	35
0.02	2	0.40	40
0.05	5	0.45	45
0.07	7	0.50	50
0.10	10	0.60	60
0.15	15	0.70	70
0.20	20	0.80	80
0.25	25	0.90	90
0.30	30	1.00	100

* These standards are very close visual matches of the chlorine-ortho-tolidine color and are preferable to temporary standards which are difficult to prepare accurately.

† *See* Sec. A–2.4.

2.6. *Modified Scott Permanent Chlorine Standards (1.0–10.0 ppm.):* The volumes of strong chromate-dichromate solution (Sec. A–2.3) indicated in Table 2 for the range of cell depths given are pipetted into 100-ml. tubes of any uniform length and diameter or into 100-ml. volumetric flasks for use in bottles. The volume is then made up to the 100-ml. mark with a 0.1 *M* phosphate buffer solution (Sec. A–2.2). These standards can be read for the cell depths given. Standards for cell depths other than those given can be prepared by interpolating between the depths stated in Table 2. Standards

TABLE 2

*Chlorine Standards—Modified Scott Formula—1.0–10.0 ppm.**

Chlorine	Chromate-Dichromate Soln.† at Cell Depth of:			
	25–50 mm.	100 mm.	200 mm.	240–300 mm.
ppm.	*ml.*	*ml.*	*ml.*	*ml.*
1	10.0	10.0	10.0	10.0
1.5	15.0	15.0	15.0	15.0
2	19.5	19.5	19.7	20.0
3	27.0	27.5	29.0	30.0
4	34.5	35.0	39.0	40.0
5	42.0	43.0	48.0	50.0
6	49.0	51.0	58.0	60.0
7	56.5	59.0	68.0	70.0
8	64.0	67.0	77.5	80.0
9	72.0	75.5	87.0	90.0
10	80.0	84.0	97.0	100.0

* These standards are very close visual matches of the chlorine-ortho-tolidine color and are preferable to temporary standards which are difficult to prepare accurately.

† *See* Sec. A–2.3.

for residuals other than those given may also be prepared by interpolation of quantities at the given cell depth.

2.7. *Comparison Tube Specifications:* Variations in the viewing depth in any set of color comparison tubes, cells or bottles used in this determination shall be not more than ± 3 per cent (15, p. 3).

2.8. *Protection of Standards:* The tubes should be protected from dust and evaporation by sealing on micro cover glasses with collodion, Canada balsam or similar material. The sealing may be applied to the top of the Nessler tube by means of a camel-hair brush and the cover glass put into position promptly with forceps. After it is spot sealed, the circumference may be reinforced with additional brush-applied sealing material until the joining of the tube and cover glass is complete. The use of rubber stoppers is not recommended. The standards should neither be stored nor used in direct sunlight. They should be renewed whenever turbidity appears.

2.9. *Commercial Standards:* Generally, more uniform results will be obtained by the use of commercially prepared permanent standards than by the use of standards prepared in individual laboratories. This is particularly true in the small water plant. Commercial permanent standard kits have the advantage of providing compensation for color and turbidity in the sample being examined.

Sec. 3—Light Sources

3.1. *Illumination:* All readings should be taken looking through the samples against an illuminated white surface. This white surface may be opaque and illuminated by reflection or may be an opal diffusing glass illuminated from behind. Since, in plant control, the chlorine determination is one which should be made both day and night, it is preferable that all comparisons be made with a standard artificial light. The permanent standards as outlined under Secs. A–2.1–2.8 give greatest

accuracy when used with either of the two artificial light sources specified in Sec. 3–3.3, both of which are close approximations of average "north" daylight.

3.2. *Natural Daylight:* If artificial light is not provided, comparisons should be made with good "north" daylight. Under no circumstances should the comparisons be made in the sunlight.

3.3. *Artificial Daylight:* This may consist of filament or fluorescent "daylight" lamp assemblies.

3.3.1. *Filament Lamp Assembly:* This should consist of a light source, color filter and diffuser glass, suitably mounted in a cabinet. It is essential that the diffuser glass be placed in contact with the color filter and on the sample side. *The light source* should be a 150-watt Mazda "C" lamp, with clear envelope. *The color filter* should be Corning Glass "Daylight" No. 5900, having a thickness equivalent to 163 micro-reciprocal degrees (mr°). *The diffuser glass* should be thin flashed opal glass without color tint.

3.3.2. *Fluorescent "Daylight" Lamp Assembly:* The white reflecting or diffusing surface may be illuminated by a fluorescent "daylight" lamp without the use of a color filter. Those manufactured by the General Electric Co. or the Westinghouse Electric and Mfg. Co. or equal should be specified.

Sec. 4—Procedure

4.1. *Addition of Sample to Reagent:* Use 0.5 ml. ortho-tolidine in 10-ml. cells, 0.75 ml. in 15-ml. cells, 5 ml. in 100-ml. tubes and the same ratio for other volumes. Place ortho-tolidine reagent in the Nessler tube, colorimeter cell or other container, add sample to the proper mark or volume and mix.

4.2. *Temperature of Sample* (16): When the temperature of the sample is less than 20°C., bring the treated sample to that temperature quickly after mixing the sample with ortho-tolidine. If a comparator cell is used, place it in hot water until the specified temperature is reached. If a Nessler tube is used, it may be handled in the same manner as the cell, or the contents may be transferred to a flask for heating. For approximate results in the field, other means of heating may be employed, but the results will not be comparable.

4.3. *Color Development and Comparison:* Place the treated sample (Sec. A–4.1) in the dark during color development. Maximum color develops in less than 5 min. and fading occurs thereafter. Reading should be taken within 5 min.

When all chlorine in the sample is in the free condition maximum color appears almost instantaneously.

Color comparison should be made against standards which occupy the same depth of tube or cell as the sample.

4.4. *Compensation for Interference:* The presence of natural color or turbidity in the sample interferes with the reading of the color developed. When viewing sample and standard horizontally, this interference may be compensated for by placing an untreated sample of the same thickness behind the standard and clear water behind the sample being compared.

Sec. 5—Temporary Chlorine Standards

5.1. *Zero-Chlorine-Demand Water:* Add sufficient chlorine to distilled water to destroy the ammonia. The amount of chlorine required will be about 10 times the amount of NH_3–N

present and in no case should the initial residual be less than 1.0 ppm. chlorine. Allow the chlorinated distilled water to stand overnight or longer; then expose to direct sunlight until all residual chlorine is discharged. The use of NH_3–N and NO_2–N free distilled water expedites obtaining a zero-chlorine-demand water (4).

5.2. *Chlorine Solution for Temporary Standards:* Chlorine solutions should be prepared by diluting commercially prepared solutions of hypochlorite, *such as "Zonite."* "Zonite" contains about 1 per cent (10,000 ppm.) active chlorine.

5.3. *Preparation of Standards:* All glassware must be aged by being filled with water containing at least 10 ppm. chlorine for a few hours before use and then rinsed with zero-chlorine-demand water.

5.3.1. Add calculated volumes of hypochlorite solution to a series of flasks containing zero-chlorine-demand water to cover the range desired. Make up each one to 500 ml.

5.3.2. Pipette 100 ml. from each flask to a series of smaller flasks, each containing 5 ml. ortho-tolidine (Sec. A–1.1). Add the chlorine solution slowly, mixing well as it is added. Pour the required amount into the comparator cell or tube. If 100-ml. Nessler tubes are used, the second series of flasks may be omitted.

5.4. *Titration of Chlorine Solution:* Pour the remaining 400 ml. chlorine water (Sec. A–5.3) into a white porcelain casserole and titrate iodometrically with acid (Secs. B–2.1.1–2.2) unless amperometric equipment (17), which is preferable, is available.

5.4.1. When the greatest accuracy is not required, suitable volumes of a chlorine solution, standardized iodometrically (Secs. B–2.1.1–2.2), may be added to zero-chlorine-demand water containing 5 ml. ortho-tolidine in a 100-ml. Nessler tube and the volume made up with the same water.

Part B—Iodometric Method

The iodometric method for the determination of residual chlorine in water can be made more precise than the ortho-tolidine method, particularly when residual chlorine is greater than 1 ppm. (14, p. 264; 18, p. 8). When the titration is made without acid, the interfering effect of nitrites and manganic and ferric salts is minimized (7). Generally, the starch-iodide method carried out in acid solution yields higher figures than the neutral starch-iodide titration (7). The acid titration therefore is preferred when interfering substances are known to be absent. Acetic acid should be used, but if not available, sulfuric acid of cp. quality may be substitute. ***Hydrochloric acid should not be used.***

Colorimetric methods for the iodometric determination of chlorine are available, but are given in this report only by reference (19).

Sec. 1—Reagents

1.1. *Potassium Iodide Solution (KI):* Dissolve 75 g. cp. potassium iodide (free from iodine and iodate) in 1.0 liter freshly boiled and cooled distilled water. If difficulty is experienced with stability of the solution, the solid substance may be used directly, since it is very soluble.

1.2. *0.01N Sodium Thiosulfate:* Stability of 0.01*N* thiosulfate is improved if it is prepared by diluting an aged 0.1*N* solution (made as directed in Sec. B–1.2.1) with freshly boiled

distilled water. Boiled water is used because bacterial action decomposes 0.01*N* thiosulfate. Trouble of this sort may be avoided by the addition of a few milliliters of chloroform. For accurate work, this solution should be standardized daily. The use of an automatic burette, of a type in which rubber does not come in contact with the solution, is advisable (20).

1.2.1. *0.1N Sodium Thiosulfate:* Make 0.1*N* sodium thiosulfate by dissolving at least 25 g. of the cp. salt in 1.0 liter of freshly boiled distilled water, standardizing it against potassium dichromate (15, p. 142; 21, p. 127) after at least two weeks' storage.

1.3. *Starch Solution:* To 5 g. starch (potato, arrowroot or soluble) in a mortar, add a little cold water and grind to a thin paste. Pour into 1 liter of boiling distilled water, stir and allow to settle overnight. Use the clear supernatant. The solution should be preserved with salicylic acid (1.25 g. per liter of starch solution). The starch may be preserved also with zinc chloride added at the rate of 4 g. per liter.

1.4. *Acid Solution:* Use either (a) a solution of acetic acid, made by diluting 500 ml. glacial acetic acid to 1.0 liter with distilled water, or (b) a solution of sulfuric acid, made by adding 20 ml. of concentrated sulfuric acid (sp.gr. 1.84) to approximately 750 ml. distilled water and diluting to 1.0 liter. Add the acid to the water slowly, with constant stirring.

Sec. 2—Procedure

2.1. *Volume of Sample:* The amount of sample to be taken for titration is governed by the concentration of chlorine in the sample. It is suggested that, for quantities of residual chlorine of 1.0 ppm. or less, 1.0 liter be titrated; for residual chlorine concentrations between 1 ppm. and 10 ppm., 500 ml.; for residual chlorine concentrations above 10 ppm., proportionately less of the sample should be used. It is preferable to use sufficient sample so that not more than 20 ml. of 0.01 *N* thiosulfate is required.

2.1.1. *Preparation for Titration:* If no interfering substances are present, place 10 ml. acid, or sufficient to reduce the pH to between 3.0 and 4.0, in a flask or white porcelain casserole, add 10 ml. of KI solution, pour in the sample and mix with a stirring rod. Omit the acid if interfering substances are present.

2.1.2. *Titration:* Add 0.01*N* thiosulfate from a burette until the yellow color of the liberated iodine is almost discharged. When liter samples are titrated, add 5 ml. starch, reducing this amount with smaller samples. The amount of starch used should be sufficient to give a deep blue color. After the addition of starch, titrate carefully, but rapidly, to the end-point. Long contact of iodine and starch produces a blue compound which is decolorized with difficulty.

2.2. *Calculation of Results:* The number of milliliters of 0.01*N* thiosulfate used in 1.0 liter of sample multiplied by 0.3546 equals the chlorine present, in parts per million.

Sec. 3—Standardization of Chlorine Solution

3.1. *Volume of Sample:* In standardizing the chlorine solution (Sec. A–5.2) for temporary standards, the volume taken for titration should be such as to require not more than 20 ml. 0.01*N* thiosulfate.

In standardizing chlorine water solution (Sec. D–1.2) for determining chlorine demand, the volume taken for

titration should be such as to require not more than 20 ml. of 0.1*N* thiosulfate.

3.1.1. *Preparation for Titration:* Proceed as in Sec. B–2.1.1. Distilled water may be added at the discretion of the analyst if a larger volume is preferred for titration.

3.1.2. *Titration:* Titrate the chlorine solution as in Sec. B–2.1.2.

3.2. *Calculation of Results:* In standardizing chlorine solution for temporary standards:

$$\text{mg./ml. chlorine} = \frac{\text{ml. } 0.01\,N \text{ thiosulfate} \times 0.3546}{\text{ml. sample titrated}}$$

In standardizing chlorine water solution for determining chlorine demand:

$$\text{mg./ml. chlorine} = \frac{\text{ml. } 0.1\,N \text{ thiosulfate} \times 3.546}{\text{ml. sample titrated}}$$

Part C—Chlorine and Chloramine Differentiation Method

Chlorine in water may be in the form of free chlorine, chloramines and other combinations of chlorine and nitrogen. One or more of these forms of chlorine may be present at the same time (8).

The only means now known for determining accurately the amount of free chlorine and the free chlorine combined with nitrogen compounds, in a mixture, is by the use of the amperometric method (17).

A workable qualitative determination of the presence of free chlorine is afforded by the Laux "flash" test (8). Before this test is used in plant control, the exact colors produced must be determined in a chlorine demand series as given in Part D, because color shades and color stability vary with pH and the amount of reagent added. The presence of oxidized manganese makes this method inapplicable.

Sec. 1—Reagents

The ortho-tolidine reagent is the same as that in Secs. A–1.1–1.2.

Sec. 2—Procedure

2.1. *Reagent and Sample:* Place a sample of the water under test in a comparator cell or small glass vessel. Hold against a white background. Using a medicine dropper, add with force from ½ to 1 ml. of ortho-tolidine reagent to the sample of water, paying close attention to color development.

2.1.1. If color development is instantaneous, free chlorine is present, unless the sample contains oxidized manganese. With practice, as little free chlorine as 0.1 ppm. may be detected in this manner.

2.1.2. Hesitation in color development indicates the presence of chloramines and not free chlorine.

Part D—Chlorine Demand Method

The chlorine demand of water is the difference between the amount of chlorine applied and the amount of residual chlorine remaining at the end of the contact period. The demand for any given water varies with the amount of chlorine applied, time of contact and temperature. For comparative purposes it is imperative that all conditions be stated. The smallest amount of residual chlorine considered at all significant is 0.1 ppm. (22, 23). Treatment of water beyond this point usually results in a series of increasing demands. Addition of that amount which will destroy the ammonia present is commonly termed "break-point" chlorination. In practice, the ratio of chlo-

rine to ammonia nitrogen (NH_3–N) at the break-point is seldom less than 10 to 1 and may reach 25 or more to 1.

All chlorine demands may be determined by following the same general procedure.

Sec. 1—Reagents

1.1. Use ortho-tolidine reagent (Secs. A–1.1 and A–1.2) or iodometric reagents (Secs. B–1.1–1.4).

1.2. *Chlorine Water Solution:* A suitable solution may be obtained from the chlorinator solution hose or by bubbling chlorine gas through water obtained from the laboratory tap. Due to instability of chlorine water, it is necessary to make up fresh solutions daily and to standardize immediately prior to the start of each test. The use of amber bottles is recommended. When hypochlorite is used in plant operation, it may be used for this test.

1.2.1. The strength of the chlorine water or hypochlorite solution should be such that the volume of the treated sample will not be increased by more than 5 per cent.

1.2.2. Standardize the chlorine solution iodometrically (Sec. B–3).

Sec. 2—Procedure

2.1. *Volume of Samples:* Measure at least ten equal portions of the water under test. Use beakers or other glass containers, such as fruit jars, of ample capacity to permit mixing the chlorine with the water. If the object of the test is simply to determine chlorine demand, the volume of the sample in each container may be no more than 100 ml. If the purpose of the test is to study bacterial removal, the effect on taste and odor or the chemical constituents of the water, samples of 500 ml. or more will be required.

2.2. *Addition of Chlorine Water:* The amount of chlorine added to the first jar should be such that no chlorine remains at the end of the contact period, especially when low demands are being studied. Add increasing amounts of chlorine to successive portions in the series. The increase between portions may be as low as 0.1 ppm. for determining low demands and up to 1.0 ppm. for exploring higher demands.

2.2.1. Mixing is imperative while the chlorine solution is being added to the sample.

2.3. *Contact Time:* To determine in advance the effect of chlorination, the plant contact time and temperature should be duplicated in the laboratory. For plant control, other and shorter contact periods at some controlled temperature generally can be found. During the contact period, the chlorinated samples must be protected from strong daylight.

2.4. *Examination of Samples:* At the end of the contact period, remove an equal amount from each portion and determine the residual chlorine by the method described in Part A or Part B.

2.4.1. It will aid in studying the results to plot the residual chlorine or the amount consumed.

2.4.2. Samples for bacteriological examination may be removed at desired intervals.

2.4.3. Taste and odor of the treated samples may be observed at ordinary temperatures without de-chlorination. For odor observation at elevated temperatures, samples should be de-chlorinated before heating. Choice of the de-chlorinating agent must be made with due regard to its effect on odor in the water under examination. Generally, sodium bisulfite, using only small excess, is satisfactory (24).

Part E—Drop Dilution Method for Field Use

This test is designed for field measurements of residual chlorine, where concentrations are greater than 10 ppm. and where speed of estimation is of importance (11). It is particularly useful in the sterilization of mains or tanks, where laboratory apparatus is ordinarily lacking. The test is not intended to displace titration methods and should not be used where extreme accuracy, such as standardization of solutions, is desired.

Sec. 1—Reagents

The ortho-tolidine reagent is the same as that in Secs. A–1.1–1.2.

Sec. 2—Procedure

2.1. *Equipment:* The determination may be made in comparators or in Nessler tubes, with due consideration given to the amount of chlorine solution taken for test.

2.1.1. The medicine dropper used in any determination by this method should be checked to see that it delivers approximately 20 drops per ml.

2.2. *Reagent and Sample:* If a comparator, in which the cell contains 10 or 15 ml., is used, place 0.5 ml. ortho-tolidine solution in the cell. If a 100-ml. Nessler tube is used, place 5.0 ml. ortho-tolidine solution in the tube.

2.2.1. Fill the cell or tube to the mark with distilled water and mix thoroughly.

2.2.2. Add to the cell or tube one drop of water under test. Mix thoroughly and read as provided in Part A.

2.2.3. If the addition of one drop of water under test produces no color, discard the contents of the cell and refill with ortho-tolidine and distilled water as before and add two drops of the water under test. Continue this procedure with increasing amounts of sample until an easily readable color (not less than 0.1 ppm.) is produced.

2.3. *Contact Time:* A sample of water with such concentrations of chlorine as may be determined by this method contains only active chlorine and traces of or no chloramine chlorine. For this reason the color development is very rapid and the reading may be made almost at once.

2.4. *Calculation:* Calculation of results may be made by using the following formula:

$$\frac{\text{volume of cell, ml.}}{\text{ml. of sample}} \times \text{reading} = \text{ppm. residual chlorine}$$

EXAMPLE:

$$\frac{15 \text{ (capac. of cell)}}{0.05 \text{ (1 drop)}} \times 0.10 \text{ (reading)} = 30 \text{ ppm.}$$

Part F—Chlorine Demand Method for Field Use

This test is designed for the measurement of the chlorine demand in the plant or the field when adequate facilities or personnel are not available to employ the more exact method (Part D). Results obtained in this test are approximations only.

Sec. 1—Reagents

1.1. Use ortho-tolidine reagent (Secs. A–1.1 and A–1.2).

1.2. *Chlorine Solution:* Use "Zonite." This preparation contains approximately 1 per cent available chlorine by weight. For this test its volu-

metric measurement is sufficiently accurate.

Sec. 2—Equipment

2.1. One medicine dropper which will deliver 20 drops per ml.

2.2. Ten 1-qt. fruit jars marked at the 500-ml. point

2.3. Ten 2-oz. bottles marked at the 20-ml. point

2.4. Glass stirring rod

2.5. Glass-stemmed thermometer

2.6. Permanent color standards prepared as specified in Sec. A–2 or commercially prepared.

Sec. 3—Procedure

3.1. *Measurement of Samples:* Fill each jar to the 500-ml. mark with the water under test. Record temperature at which samples are held.

3.2. *Addition of Chlorine:* While stirring constantly, add 1 drop "Zonite" to water in the first fruit jar, 2 drops to that in the second jar, 3 drops to that in the third jar, etc. Each drop of "Zonite" represents a chlorine dose of 1.0 ppm.

3.3. *Contact Time:* The contact time is a variable factor depending entirely on the results desired. Generally, the purpose of a chlorine demand test is to determine the amount of chlorine required to produce a definite residual after a definite time interval. It is recommended, therefore, that the testing be carried out at the end of the contact period corresponding to the contact at the point of control. This may vary all the way from a few minutes to several hours. Under some circumstances it is desirable to make several chlorine determinations at different times of contact, such as 15, 30, 60 min., etc. Such a procedure will give an indication of the stability of the chlorine as related to time, which will be very useful information in plant control.

The time of contact must be recorded. During the contact period the chlorinated samples must be protected from strong daylight.

3.4. *Examination of Samples:* At the end of the contact period, remove a 20-ml. portion from each sample, place it in a 2-oz. bottle and add 1 ml. ortho-tolidine to each 20 ml. Determine residual chlorine by comparison with permanent standards.

3.5. *Calculation:* Subtract the amount of residual chlorine (in ppm.) found in examination of samples from the amount of chlorine added (in ppm.). The result will be the chlorine demand (in ppm.) of the sample at the respective dosage, contact time and temperature. Plotting the residual chlorine or the amount consumed will aid in studying the results.

References

1. Hulbert, Roberts. Chlorine and the Ortho-tolidine Test in the Presence of Nitrite. Jour. A.W.W.A., **26**: 1638 (1934).
2. Scott, R. D. Effect of Iron in the Determination of Residual Chlorine. Jour. A.W.W.A., **26**: 1234 (1934).
3. Scott, R. D. Eliminating False Chlorine Tests. Jour. A.W.W.A., **26**: 634 (1934).
4. Adams, Howard W. & Buswell, A. M. Ortho-tolidine Test for Chlorine. Jour. A.W.W.A., **25**: 1118 (1933).
5. Griffin, A. E. Evaluation of Residual Chlorine. Jour. A.W.W.A., **27**: 888 (1935).
6. Race, J. *Chlorination of Water.* John Wiley, New York (1918).
7. Hallinan, F. J. & Thompson, W. R. A Critical Study of the Thiosulfate Titration of Chlorine. J. Am. Chem. Soc., **61**: 265 (1939).
8. Laux, P. C. Break-Point Chlorination at Anderson. Jour. A.W.W.A., **32**: 1027 (1940).

9. McCrumb, F. R. Elimination of Errors in the Ortho-tolidine Method. J.N.E.W.W.A., **41**: 386 (1927).
10. Dragt, G. with Mellon, M. G. Solutions for Colorimetric Standards. Permanent Series for the Ortho-tolidine Method for Chlorine. Ind. Eng. Chem. —Anal. Ed., **10**: 256 (1938).
11. Griffin, A. E. & Chamberlin, N. S. Estimation of High Chlorine Residuals. Jour. A.W.W.A., **35**: 571 (1943).
12. Chamberlin, N. S. & Glass, J. R. Colorimetric Determination of Chlorine Residuals up to 10 ppm. With Ortho-tolidine. Jour. A.W.W.A., **35**: 1065, 1205 (1943).
13. Davis, W. S. & Kelly, C. B. Photodiscoloration of Ortho-tolidine and Artificial Standards for Free Chlorine Test in Water. Jour. A.W.W.A., **26**: (1934).
14. Kolthoff, I. M. & Sandell, E. B. *Textbook of Quantitative Inorganic Analysis.* Macmillan Co., New York (1936).
15. *Standard Methods for the Examination of Water and Sewage.* Am. Public Health Assn. & Am. Water Works Assn., New York (8th ed., 1936).
16. Chlorine-Ammonia Treatment of Water. *Committee Report.* Jour. A.W.W.A., **33**: 2113 (1941).
17. Marks, H. C. & Glass, J. R. A New Method of Determining Residual Chlorine. Jour. A.W.W.A., **34**: 1227 (1942).
18. Snell, F. D. & Snell, C. T. *Colorimetric Methods of Analysis.* Van Nostrand, New York (2nd ed., 1936).
19. Gilcreas, F. W. & Hallinan, F. J. Iodide Technic for Colorimetric Determination of Chlorine in Water. Jour. A.W.W.A., **31**: 1723 (1939).
20. Kassner, J. L. & Kassner, E. E. Preparation of Stable Sodium Thiosulfate Solutions. Ind. Eng. Chem.—Anal. Ed., **12**: 655 (1940).
21. Sutton, Francis. *Volumetric Analysis.* Blakiston, Philadelphia (12th ed., 1935).
22. Streeter, H. W. Progress Report on Studies of Water Chlorination. Jour. A.W.W.A., **35**: 421 (1943).
23. Costigan, Stella M. A Bacteriologist Looks at Chlorine. Jour. A.W.W.A., **34**: 353 (1942).
24. Faber, Harry A. Super-Chlorination Practice in North America. Jour. A.W.W.A., **31**: 1539 (1939).

Some Chemical Aspects of the Ammonia-Chlorine Treatment of Water

By W. Allan Moore, Stephen Megregian and C. C. Ruchhoft

THE reaction between chlorine and ammonia as applied to water treatment has been the subject of numerous investigations. This has been particularly true since rediscovery of the break-point phenomena in 1939 stimulated the interest in this reaction. However, a good part of the work done in measuring bactericidal values of "chloramine" in chlorine and ammonia treatment is of limited value. Few investigators have been certain of what bactericidal agents were actually present in their water samples. Contradictory results were obtained by different workers, no doubt because they were working with unlike bactericidal agents under different conditions, although all agents were termed "chloramine." It will be difficult to interpret bactericidal results correctly until methods are made available for determining the chemical entities involved under various conditions in water samples which are dosed with chlorine and ammonia.

In the reaction between chlorine and ammonia, Chapin (1) has postulated that, at pH values above 8.5, only monochloramine is formed and that between 8.5 and 4.4 both the mono and dichloro derivatives exist, the relative proportions depending upon the pH of the solution. It must be remembered, however, that he was working with 0.1 *M* ammonium acetate and 1000–2000-ppm. chlorine solutions. These same facts do not necessarily hold true for ammonia and chlorine concentrations of 0.05–0.5 and 0.5–10.0 ppm. respectively.

Harvill, Morgan and Mauzy (2) in their study of break-point chlorination found a chlorine : ammonia-nitrogen ratio of 7.6 : 1 at the break-point and assumed that on the down slope of the curve, the NH_3 is oxidized to N_2. Griffin and Chamberlin (3), on the other hand, obtained ratios at the break-point varying from 9.5 : 1 to 10 : 1. These ratios are too high for the assumption that N_2 is the end-product of the oxidation. The evidence seems to indicate that the reaction is not a simple one, for N_2O, NO_2 and NO_3, besides N_2, have also been recognized as end-products (4). In view of the fact that $NHCl_2$ should be relatively hard to form and, once

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This paper was presented at the 1943 Detroit meeting of the American Chemical Society and has, at the request of the authors, been released by the A.C.S. for publication in this JOURNAL.

formed, should be quite stable, it is doubtful if any of the dichloro compound is formed in the chlorine-ammonia reaction at the concentrations regularly employed in the treatment of water.

Because many discrepancies exist as to the chlorine-ammonia reaction, the present study was undertaken to examine the methods of analysis, to consider the products formed and to determine the effect of pH, contact time and the chlorine-ammonia ratios. The break-point curve was followed with respect to the presence of free chlorine, chloramine, the disappearance of ammonia and the potentials developed in the system.

Analytical Methods

Although there are a number of substances that should be determined in studying this reaction, at present, dependable methods are available only for total residual chlorine, free residual chlorine, chloramine chlorine and total ammonia-nitrogen. In preliminary work, a number of procedures for making each of these determinations were studied. On the basis of this work, the acid-ortho-tolidine test was selected in preference to starch-iodide titration for total available residual chlorine. The Laux (5) flash test was abandoned for free residual chlorine and a method using *p*-aminodimethylaniline as proposed by a number of men (Kolthoff (6), Alfthan (7) and Haase and Gad (8)) was developed, as described elsewhere (9), and used both as a flash test and for quantitative determination of free residual chlorine.

Comparative experiments with the diethyl and dimethyl derivatives of *p*-phenylenediamine indicate that, of the two, the dimethyl derivative was the more sensitive for free chlorine.

In the quantitative determination with the above indicator, standards made up with dilute $KMnO_4$ solution and also the acid methyl-red standard advocated by Byers and Mellon (10) proved to be relatively unstable and unsatisfactory. The standards finally adopted and described (9) were made up from dilute basic fuchsin and copper acetate solutions.

The Laux-Nickel (11) neutral ortho-tolidine test for free residual chlorine was also studied, but its sensitivity appeared to be approximately 0.2 ppm. chlorine. Consequently, its use was discontinued as less satisfactory than the *p*-aminodimethylaniline test.

Chloramine Chlorine

A comparative study of the McNamee (12), Griffin (13) and time-differential ortho-tolidine tests for chloramine chlorine failed to give concordant results and uncovered difficulties with all of these procedures. The results obtained by difference between acid ortho-tolidine and the flash *p*-aminodimethylaniline test were considered preferable to any of the above for chloramine chlorine. In addition, an apparatus was constructed using a Marks (14) titrator cell for determining chloramine. This special cell was loaned to the laboratory by Wallace and Tiernan Co., Inc. Titration of the neutral sample using standard arsenious acid, followed by titration after the addition of potassium iodide with this apparatus, was found to be of great value in the determination of free chlorine and chloramine.

Total Ammonia-Nitrogen

As there are no dependable methods for determining free ammonia-nitrogen and chloramine-nitrogen separately, total ammonia-nitrogen only was de-

termined. Preliminary tests in this laboratory have shown that direct Nesslerization does not give the uncombined NH_3. The recovery of NH_3 by this procedure is affected by the magnitude of the chlorine dose (15) and complete recovery is obtained only in samples containing chlorine: ammonia ratios of less than 2:1 (16). De-chlorination of samples by thiosulfate or acid sulfite increased the amount of ammonia-nitrogen recovered by direct Nesslerization (17). The ammonia recovery by distillation is greater than that indicated by direct Nesslerization and complete recovery by distillation depends upon previous de-chlorination of the sample. In this study, therefore, total ammonia-nitrogen was determined by de-chlorinating the sample with sulfite, adjusting the pH to 7.2–7.3, distilling and Nesslerizing the distillate.

In addition to the above determinations, the oxidation-reduction potential as measured by a gold electrode against a saturated calomel half cell was determined with a Leeds & Northrup Type K potentiometer on all samples.

Procedure

One of the prerequisites of the laboratory study of the chlorine-ammonia reactions is the availability of a chlorine-demand-free distilled water. It is not sufficient to take into consideration the free ammonia present in a distilled water because there are present other oxidizable compounds, such as nitrites, which will cause a deviation in the chlorine-ammonia ratios.

A satisfactory chlorine-demand-free water was prepared by dosing distilled water (buffered at the desired pH) with 2–3 ppm. free chlorine and allowing it to stand for several days. It was then de-chlorinated to approximately 0.1 ppm. with the calculated amount of sodium sulfite, boiled for about a half hour and tested for residual chlorine. As a rule, the water was found to be chlorine-free; but, if any residual remained, further de-chlorination and boiling were carried out.

The procedure in studying the breakpoint phenomenon was as follows: To a series of 1-liter portions of the chlorine-demand-free water was added sufficient ammonium chloride solution to give a concentration of 0.5 ppm. ammonia-nitrogen. Following this, the calculated amount of hypochlorite or chlorine solution was added to give the desired dosage of chlorine and the mixture allowed to stand for the selected contact time, which was varied from 1 to 24 hr.

At the end of the desired contact time, samples were removed and some or all of the following tests were run: residual chlorine by the ortho-tolidine method, free chlorine and chloramine with the Marks' titrator, qualitative "flash test" for free chlorine using *p*-aminodimethylaniline hydrochloride, quantitative free chlorine using the same indicator, the oxidation-reduction potential and total ammonia-nitrogen.

Results

In Fig. 1 are shown typical breakpoint curves obtained at pH values from 6.0 to 9.0 and with a 24-hr. contact period. From this figure, a similarity is noted in the ortho-tolidine curves, the same type of curve being obtained regardless of the pH. However, two distinct differences are noted in the potential curves for different pH values. First the slope of the curve to the hump portion is much steeper for given chlorine dosages at the lower pH value. In fact, the initial slope decreases progressively as the pH is in-

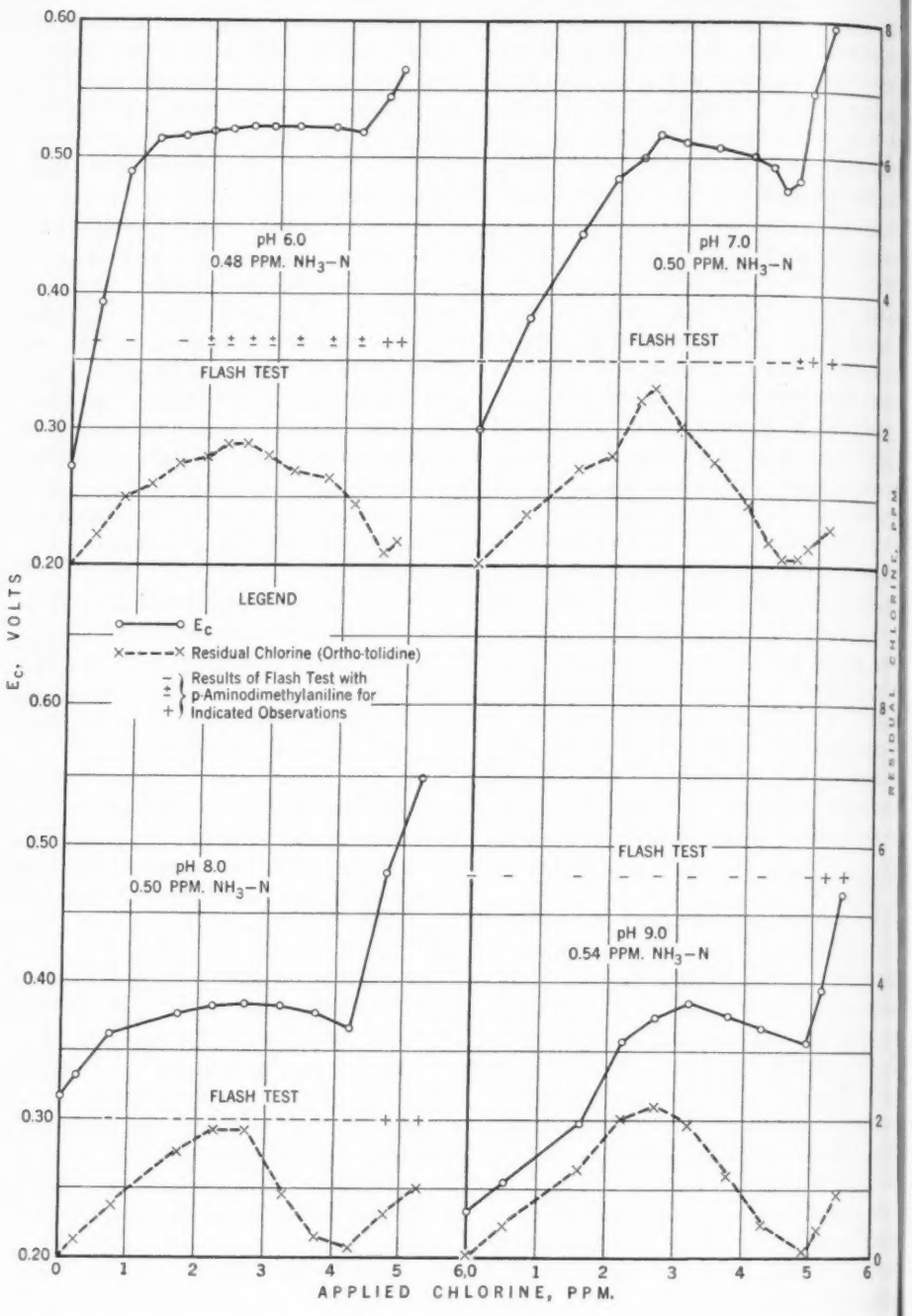

FIG. 1. Break-Point Curves After 24-Hr. Contact Period for Various pH Values

creased. Second, at the lower pH value (6.0) a very slight drop in potential is obtained between the hump portion and the break-point. This relatively flat section between the hump and the break-point is obtained at the lower pH value regardless of contact time. In the case of the higher pH values, a distinct drop in potential is found between the hump and the break-point.

The sharp rise in the potential curves past the break-point denotes the presence of free chlorine and indicates that all of the chloramine has been oxidized. The *p*-aminodimethylaniline "flash" test also confirms the presence of free chlorine beyond the break-point and its absence in other portions of the curve. At a pH of 6.0 this latter test shows a plus-minus reaction, the reason for which will be discussed later. Another feature of these curves that should be pointed out is the discrepancy occurring in some cases between the break-points as found by the orthotolidine residual chlorine test and by the potential method, the former showing a minimum residual when free chlorine was actually present.

As mentioned previously, at a pH value of 6.0 the same type of potential curve was obtained regardless of the contact time between the ammonia and applied chlorine. This is shown graphically in Fig. 2. The slope of the curve in the case of the 2-hr. contact period is seen to be much steeper once the break-point is passed than with the longer contact times. However, a striking difference in the orthotolidine residual chlorine curves is noted in that a very slight drop was found from the "hump" portion to the break-point. The 5- and 24-hr. orthotolidine curves, however, display the typical break-point phenomenon. In the plus-minus flash obtained with the *p*-aminodimethylaniline in this experiment, the color developed in approximately two seconds, which indicated a very low free residual chlorine.

The fact that, at pH 6.0, the potential curve shows no distinct drop from the hump to the break-point seems to be correlated with the plus-minus reaction obtained with the flash test. Although the reason for this lack of drop in potential has not been proved, a logical explanation would be the partial reversal of the chlorine-ammonia reaction at the lower pH value, which would result in the liberation of free chlorine and thus maintain the potential at the higher level. The "flash" test appears to substantiate this theory in that a small amount of free chlorine seems to be present after the "hump" portion of the curve is reached. This seems to be a reasonable explanation since it is a well known fact that an increase in the hydrogen-ion concentration favors the decomposition of chloramine.

Having studied the effect of pH upon the break-point curve, it was decided to follow the curve at a given pH (7.0) with the contact time varied from 1–24 hr., by using the before-mentioned analytical methods. The results are shown graphically in Figs. 3–6.

In these figures it is noted that, regardless of the contact time, there was little change in the ammonia-nitrogen until a chlorine : ammonia-nitrogen ratio of 5 : 1 was reached, at which point (hump portion) the ammonia-nitrogen concentration dropped and continued to fall until the break-point was passed. Observations for each contact period indicated that the ammonia-nitrogen had been completely destroyed beyond the break-point. It may be pointed out that, although the minimum poten-

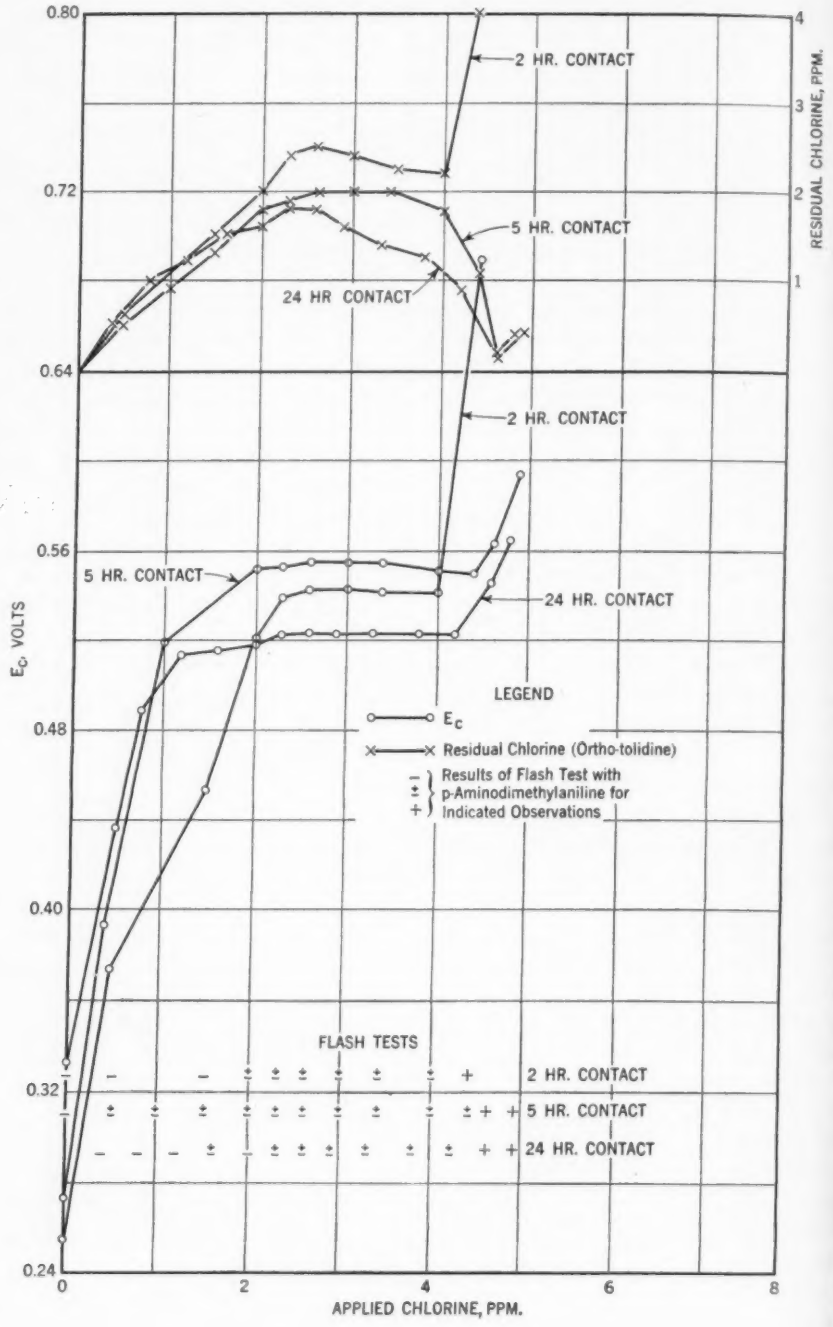

FIG. 2. Break-Point Curves at pH 6.0 for Various Contact Times, 0.5 ppm. NH_3-N

tial point after the hump is referred to here as the break-point, the true break-point may really occur at some chlorine-ammonia ratio between this minimum potential and the following point which shows a decided rise in potential. In the same way, after the hump portion of the curve, the residual chlorine minimum indicates the approximate position of the break-point, but not necessarily its exact position. For this reason exact correspondence between the break-points as indicated by the potential curve and residual chlorine determinations and the disappearance of the ammonia-nitrogen cannot be expected in these experiments.

The chlorine residual as determined by the ortho-tolidine and Marks titrator methods, gave essentially the same type of curve until the break-point was reached. At that point, the chloramine concentration, as measured by the latter method, fell to a negligible value, indicating the absence of chloramines beyond the break-point. The latter method gave slightly lower residual chlorine values in all cases. On the other hand, the free chlorine as determined by the Marks titrator remained practically at zero until the break-point was reached. As pointed out previously, however, the ortho-tolidine residual chlorine curve does not always indicate the true break-point and is not considered as reliable as other methods.

The potential curves show the typical break-point phenomenon, the major difference being the increase in the potential drop from the "hump" to the break-point as the contact time is increased.

In the quantitative determination of free chlorine with *p*-aminodimethylaniline, an error is noted due to oxidation by dissolved oxygen at the higher pH value. This error is relatively constant amounting to approximately 0.05 ppm. chlorine after a 3-min. contact.

An examination of both the quantitative and qualitative *p*-aminodimethylaniline residual chlorine curves in Figs. 3–6 shows that, in all cases, these procedures indicated the same break-point as the potential readings. This is another reason for concluding that the break-point as determined by these three criteria is most reliable.

An examination of the curves obtained after 2- and 24-hr. contact, as shown in Figs. 4 and 6, indicates that free chlorine was actually present (as determined by the potential and the *p*-aminodimethylaniline methods) when the ortho-tolidine curve indicated a minimum. This additional evidence also indicates that ortho-tolidine residual chlorine data are somewhat less reliable for determining the approximate break-point.

Discussion

Even though other investigators have found break-point chlorine : ammonia-nitrogen ratios indicating various values, better agreement is found in the ratios for the "hump" of the break-point curve. Harvill, Morgan and Mauzy (2) found this to occur at a chlorine : ammonia-nitrogen ratio of about 5 : 1. The present study also confirms this. If this is true, then the reaction between chlorine and ammonia must produce the monochloramine according to the equation:

$$NH_3 + Cl_2 \rightarrow NH_2Cl + HCl$$

which gives a chlorine : ammonia-nitrogen ratio of 71 : 14, or 5.07 : 1. This indicates that no dichloramine is formed at the chlorine-ammonia ratios employed up to the hump portion of the break-point curve.

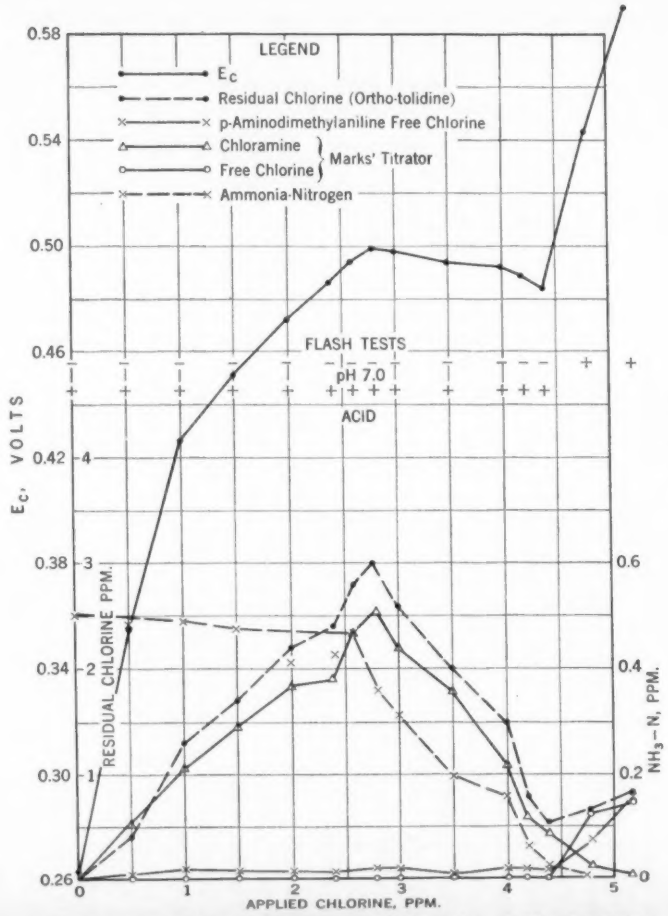

Fig. 3. Break Point Curves at pH 7.0 After 1 Hr. Contact

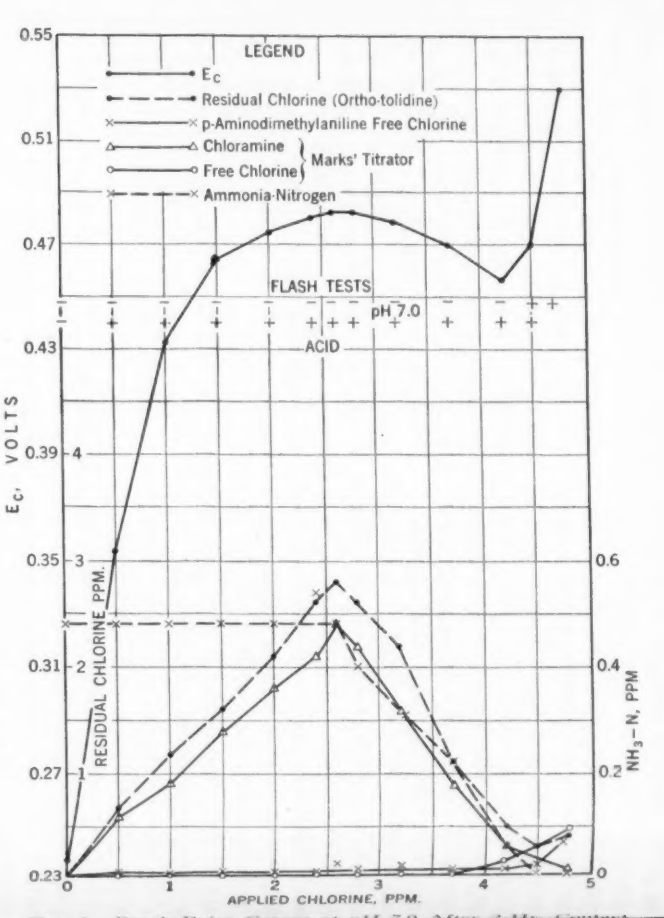

Fig. 4. Break Point Curves at pH 7.0 After 2 Hr. Contact

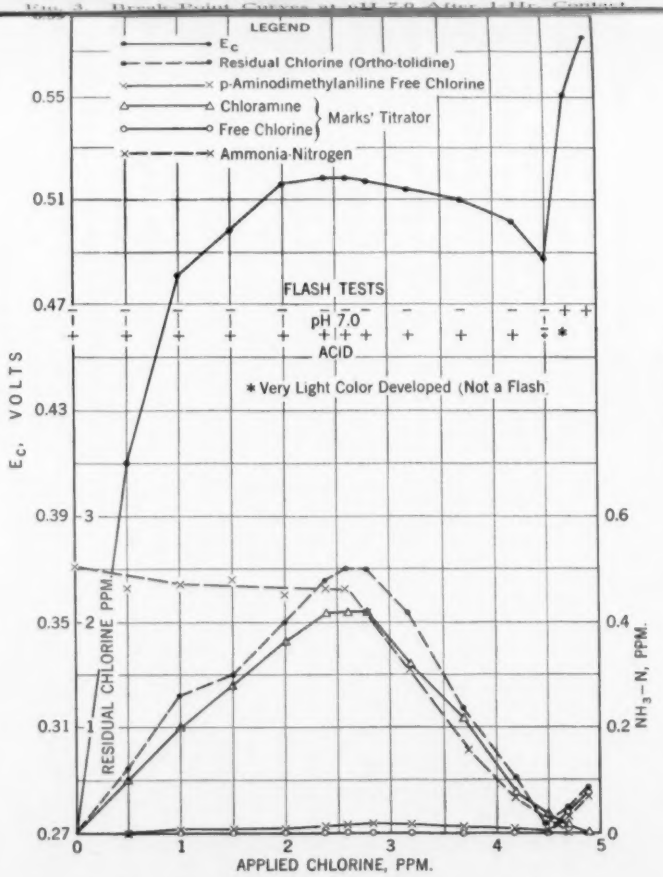

FIG. 5. Break-Point Curves at pH 7.0 After 3-Hr. Contact

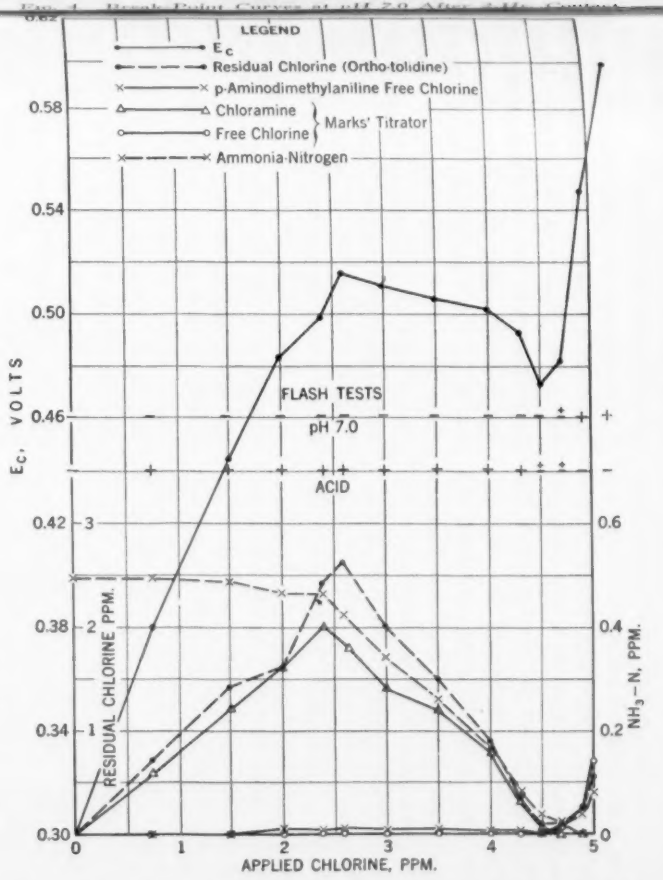

FIG. 6. Break-Point Curves at pH 7.0 After 24-Hr. Contact

At the break-point, however, as pointed out previously, various values of the ratio have been found, some as high as 25 : 1. In those cases where ratios greater than 10 : 1 are encountered, it is logical to assume that the water contains ammonia that is not taken into consideration, as well as nitrogenous organic material having an appreciable chlorine demand.

In Table 1 are given the maximum and minimum chlorine : ammonia-nitrogen break-point ratios taken from the curves presented here as determined by the potential and "flash" methods and not by actual determination of residual chlorine. The minimum values are the ratios of the minimum point, which is ordinarily considered the break-point, and the maximum value, which is the ratio at the next point beyond the minimum.

TABLE 1

Minimum and Maximum Chlorine: Ammonia-Nitrogen Ratios at Break-Point

Minimum	Maximum
8.4	9.2
9.0	9.5
8.0	9.0
9.1	9.4
8.6	9.4
8.8	9.4
8.8	9.2
9.0	9.4
Avg. 8.7	9.3
Mean 9.0	

Assuming the following reaction to take place from the "hump" to the break-point:

$$4NH_2Cl + 3Cl_2 + H_2O \rightarrow N_2 + N_2O + 10HCl$$

the chlorine required to carry the reaction through this portion of the curve would be 212.76 : 56 or 3.79 : 1. From these figures, the break-point should come at a chlorine : ammonia-nitrogen ratio of $5.07 + 3.79 = 8.86$, which approximates the average minimum break-point ratio found, as shown in Table 1. This ratio may be contrasted with the 7.6 : 1 ratio found by Harvill (based on the starch-iodide method) and assumed to indicate that all of the NH_3 is oxidized to N_2. As other decomposition products than N_2 have been identified, it would seem that Harvill's ratio is low. As pointed out previously, the break-point ratios found do not depend upon the determination of actual residual chlorine but upon potential curves and the *p*-aminodimethylaniline "flash" test results. They are, therefore, not subject to the inherent errors of the common methods for determining residual chlorine.

If the reaction from the "hump" portion of the curve to the break-point is the decomposition of the monochloramine previously formed, then the "flash" test should show little color on acidification near the break-point. This has been found to be true, for in one or two cases, where conditions were fortunately just right, a negative reaction was obtained with the "flash" test both at the higher buffered pH and also upon acidification, indicating that no chloramine was present at or beyond the break-point. This is also substantiated by the fact that the recoverable ammonia drops to zero at the break-point. It should also be pointed out that an entirely different type of NH_3 recovery curve would be obtained if NCl_3 were present previous to the break-point, as postulated by Irwin (18). Its presence is also incompatible with pH values above 4.4 (1).

The fact that, at a pH value of 7.0, essentially the same type of curves are obtained regardless of contact time indicates that the reaction between chlorine and ammonia is quite rapid. This is also shown by the data given in Table 2, for reactions in which approximately 3 min. elapsed between the addition of the chlorine to water containing 0.50 ppm. NH_3 and at a pH of 7.0. The last column of Table 2 shows that chlorine was released upon acidifying the negative flash test thereby indicating that chloramine was present.

TABLE 2

Rate of Reaction Between Chlorine and Ammonia as Indicated by Results After 3-Min. Contact

Cl : N Ratio	Ortho-tolidine, *ppm.*	Flash	
		pH 7.0	Acid
0.5 : 1	0.25	−	+
1 : 1	0.60	−	+
2 : 1	1.10	−	+
3 : 1	1.50	−	+
4 : 1	2.00	−	+
5 : 1	2.40	+	+

Summary

A study of the reactions of chlorine and ammonia was made in chlorine-demand-free distilled water. After a preliminary study, the following most dependable chemical determinations were used:

1. Total residual chlorine by the ortho-tolidine method
2. Free residual chlorine by the flash and quantitative *p*-aminodimethylaniline methods
3. Free and chloramine residual chlorine by the Marks titrator
4. Oxidation-reduction potential
5. Total ammonia-nitrogen.

Analysis of the data indicates that the "flash" *p*-aminodimethylaniline test for free chlorine and the oxidation-reduction potential determination are the most sensitive and reliable indicators of the break-point in the chlorine-ammonia reaction. It has been shown that the ortho-tolidine method in some cases indicates a false break-point. The Marks titrator checks the *p*-aminodimethylaniline flash test in showing no free chlorine up to the break-point. Both of these methods also indicate no chloramine-chlorine beyond the break-point, thereby checking the ammonia data.

The hump portion of the break-point curve was found to occur at a chlorine : ammonia-nitrogen ratio of approximately 5 : 1 and the break-point at a ratio of about 9 : 1. With contact periods varying from 2 to 24 hr. essentially the same type of break-point curve was obtained in the 6.0–9.0 pH range studied. The chlorine-ammonia reaction was found to be quite rapid, for no evidence was obtained of free residual chlorine within 3 min. after its addition at pH 7.0 for all chlorine : ammonia ratios below the hump. The study at the lower pH value (6.0) indicated that a reversal of the reaction between chlorine and ammonia occurs after the hump portion of the break-point curve is reached. This reversal is indicated by the flat character of the potential curve and the plus-minus reaction of the flash test in this section.

The authors wish to acknowledge the assistance received from Asst. Chemist J. F. Kachmar of the Cincinnati Stream Pollution Investigation Staff in the preliminary study of the literature and the analytical procedures.

References

1. Chapin, R. M. Dichloro-amine. J. Am. Chem. Soc., **51**: 2112 (1929).
2. Harvill, Clyde R., Morgan, J. H. & Mauzy, H. L. Practical Application of Ammonia-Induced Break-Point Chlorination. Jour. A.W.W.A., **34**: 275 (1942).
3. Griffin, A. E. & Chamberlin, N. S. Relation of Ammonia-Nitrogen to Break-Point Chlorination. Am. J. Pub. Health, **31**: 803 (1941).
4. Chapin, R. M. The Influence of pH Upon the Formation and Decomposition of the Chloro Derivatives of Ammonia. J. Am. Chem. Soc., **53**: 912 (1931).
5. Laux, P. C. Break-Point Chlorination at Anderson. Jour. A.W.W.A., **32**: 1027 (1940).
6. Kolthoff, I. M. Detection and Determination of Free Chlorine in Drinking Water. Chem. Weekblad (Neth.), **23**: 203 (1926).
7. Alfthan, Knut [*Translated by* A. C. Jarvis]. A New Indicator for Chlorine. Jour. A.W.W.A., **20**: 407 (1928).
8. Haase, L. W. & Gad, G. The Determination of Free Chlorine in Water Using Dimethyl-*p*-phenylenediame. Z. Anal. Chem. (Ger.), **107**: 1 (1936).
9. Moore, W. Allan. Use of *p*-Aminodimethylaniline as an Indicator for Free Chlorine. Jour. A.W.W.A., **35**: 427 (1943).
10. Byers, D. H. & Mellon, M. G. Colorimetric Determination of Chlorine With *p*-Aminodimethylaniline. Ind. Eng. Chem.—Anal. Ed., **11**: 202 (1939).
11. Laux, P. C. & Nickel, J. B. A Modification of the Flash Color Test to Control Break-Point Chlorination. Jour. A.W.W.A., **34**: 1785 (1942).
12. McNamee, P. D. Estimation of Chloramine in Water Supplies. Ind. Eng. Chem.—Anal. Ed., **7**: 333 (1935).
13. Griffin, A. E. New Chlorine-Chloramine Differential Test Proposed. W. W. Eng., **92**: 1039 (1939).
14. Marks, H. C. & Glass, J. R. A New Method of Determining Residual Chlorine. Jour. A.W.W.A., **34**: 127 (1942).
15. Howard, N. J. Discussion on Water Purification. Jour. A.W.W.A., **32**: 1198 (1940).
16. Frisk, P. W. & Conrad, A. J. Determining Residual Ammonia in the Presence of Chloramine. Jour. A.W.W.A., **31**: 1197 (1939).
17. Calvert, C. K. Treatment With Copper Sulfate, Chlorine and Ammonia. Jour. A.W.W.A., **32**: 1155 (1940).
18. Irwin, Clyde H. Observations Regarding Break-Point Chlorination. Ohio Conf. Water Purif., **20**: 41 (1940).

Discussion

C. K. Calvert *

The writer's review of the paper by Messrs. Moore, Megregian and Ruchhoft leads him to point out certain factors with which he takes issue. First of these is the fact that throughout the paper, the matter of temperature is not mentioned. Table 2, for instance, shows the speed with which the chlorine and nitrogen unite, but there is a great deal of difference in this rate of reaction at high temperatures and at low temperatures which is not taken into account. As a practical matter, in purification plants, water must be treated to the break-point at very close to 0°C.

Temperature is an important factor in considering the effect of time, but what is more important, particularly with the long contact periods studied, is the amount of slowly oxidizable material in the water. The effect of time varies with the type of nitrogenous matter being chlorinated. In a pure water, with a clean ammonium salt such as ammonium chloride or ammonium sulfate, the change in the curve is slight with added time in con-

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trast to the change that takes place when, for example, amino-acetic acid is chlorinated. In the latter case, the curve, particularly beyond the break-point, falls decidedly with added contact time. The same is true of curves for certain raw waters which appear to contain simple amines, but which are less easily completely oxidized than the plain ammonia salts.

The ratio between chlorine and nitrogen is a very sensitive one which may be determined precisely only if the increments of either chlorine or nitrogen are small. In one experiment in which the chlorine was kept constant and the ammonia varied, the residual chloramine changed at the critical point from about 0.5 ppm. to 1.0 ppm. with the addition of 0.01 ppm. nitrogen as ammonium chloride. With the addition of another 0.01-ppm. quantity, the residual increased to a little more than 2 ppm. In another series, the addition of 0.01 ppm. nitrogen increased the residual chloramine at the critical point from about 0.75 to 1.6 ppm., and the second 0.01 ppm. nitrogen raised it to 3.2 ppm. In both of these runs, the water contained 8–10 ppm. chlorine before ammonia was added. These results are given as an example of the very profound effect of minute quantities of nitrogen. They may explain, in part, variations in the chlorine-nitrogen ratios reported by different investigators.

If direct Nesslerization is used, it is quite unnecessary to de-chlorinate before adding the Nessler reagent, since the reagent is not affected by even quite large quantities of chlorine. Ammonia combined more or less loosely with chlorine will not produce color with Nessler reagent. If ammonia is to be determined by distillation, de-chlorination must be carried out before distillation, because some of the chloramines are carried over in distillation. It depends on what one wants to learn whether the ammonia in a chlorinated sample should be determined by direct Nesslerization or by distillation.

It is interesting to note that the curves obtained by the authors agree very closely with those published by Griffin and Chamberlin (Jour. A.W.W.A., **35**: 571 (1943)), who used the distillation method. An entirely different shape of curve obtains when direct Nesslerization, without de-chlorination, is used. If de-chlorination is carried out before direct Nesslerization, thiosulfate is not suitable because it affects the color of the Nesslerized sample. Bisulfite is very much less objectionable.

Personally, the writer prefers direct Nesslerization, because it shows what ammonia is still available for reaction with chlorine at a particular point on the curve. It does not, however, show what ammonia may be available for reaction with chlorine at some other point on the curve.

The chlorine : nitrogen ratio still seems to be 7.5 : 1 when *net* chlorine and ammonia-nitrogen destroyed are considered. The various figures developed by others are, of course, founded on their own work. The reactions taking place through a break-point curve are difficult to determine because of the great dilution in a practical range.

Harry A. Faber *

Only a few years ago, it was generally accepted that little basic information was lacking with regard to the mechanism of water disinfection by chlorine or chlorine-ammonia treatment. Recent studies by a number of

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investigators, however, have provided an entirely new conception of the complexity of the reactions involved. The eventual contribution of research, such as that presented in the paper by Messrs. Moore, Megregian and Ruchhoft, will be toward a more thorough understanding of the chlorination process and its practical application with greater efficiency and dependability.

Some of the results and conclusions offered by these authors appear to be contrary to the results and conclusions of other investigators. The other investigators are in disagreement among themselves. But it is in the minor details and in those considerations less important in a practical sense that the disagreement exists. This condition is typical of any new field of investigation. Only when sufficient data have been accumulated can the significance of these chemical reactions be fully evaluated.

In such laboratory studies, it is essential to employ distilled water and to control all conditions in order to reveal basic facts. It is important to realize that identical conditions do not necessarily apply to the chlorination of a heavily polluted raw water supply. Thus, the operation of a water purification process has always been partly art and partly science, but chlorination has proved its value even under such conditions. It may confidently be expected that research studies of this nature will contribute to improved control of the chlorination process.

Authors' Closure

It is true that no mention of temperature is made. However, as a general rule, when no specific temperature is mentioned, room temperature is understood. Room temperature during these experiments was about 25°C. It was realized that this was much higher than water temperatures usually encountered in practice. The rate for the ammonia-chlorine reaction would be approximately doubled for each 10 deg. rise in temperature. Except in the case of the data shown in Table 2, however, the authors were primarily interested in the break-point curve after equilibrium was attained. In these cases temperature should have no effect upon the shape of the break-point curve.

The authors agree with Mr. Calver that *time* is an important factor in studying the reaction between chlorine and various types of nitrogenous material. In this paper, however, it is stated specifically that the reaction between chlorine and free ammonia and chloramine in a system previously freed of all oxidizable organic material is being studied.

In the precise determination of the chlorine-ammonia ratio at the break-point, small increments of the reactants must be used. In working with the concentrations of either usually encountered in actual practice, however, the analytical errors involved are often greater than the increments used. This was found to be true in some of the experiments. It was therefore necessary to resort to expressing the break-point ratios by giving maximum and minimum ratios, the mean of which should be fairly close to the true ratio as shown in Table 1.

The authors agree that direct Nesslerization will give an entirely different type of curve than with the distillation method. The former measures the unreacted ammonia and the latter measures the breakdown of ammonia. In order to follow the entire break-point curve it is necessary to use the latter method. It was for this reason that the distillation method following

de-chlorination with sulfite was used. The only portion of the break-point curve in which direct Nesslerization is of any value is that portion up to the "hump," at which point all of the ammonia has reacted with chlorine to form chloramine. From the "hump" to the break-point, chloramine is being oxidized and the residual chloramine will not react with the Nessler reagent.

As pointed out previously, it is extremely difficult to determine the precise chlorine-ammonia ratio at the break-point, due to the fact that very small increments of chlorine must be added. As shown in the curves, however, ammonia is not recoverable past the break-point; therefore, there should be a point at which the ammonia concentration becomes equal to zero, which point would be the precise break-point. Also at this point the chlorine concentration would be equal to zero. It is, therefore, not possible to consider *net* ammonia or chlorine present but the ratio must be considered as occurring between two points on the curve. In one of the experiments, the authors were fortunate enough to hit the exact break-point, neither chlorine nor chloramine being present.

In this same connection some investigators have reported the re-occurrence of ammonia beyond the break-point and, at the same time, have shown the residual chlorine to be a straight line function of the applied chlorine. This seems inconsistent, for if free ammonia were recoverable beyond the break-point, it should react with the applied chlorine, so that a straight line function would not be obtained.

Abstracts of Water Works Literature

Key: In the reference to the publication in which the abstracted article appears, **34:** 412 (Mar. '42) indicates volume 34, page 412, issue dated March 1942. If the publication is paged by the issue, **34:** 3: 56 (Mar. '42) indicates volume 34, number 3, page 56, issue dated March 1942. Initials following an abstract indicate reproduction, by permission, from periodicals, as follows: *B.H.—Bulletin of Hygiene (British); C.A.—Chemical Abstracts; P.H.E.A.—Public Health Engineering Abstracts; W.P.R.—Water Pollution Research (British); I.M.—Institute of Metals (British).*

LAW, LITIGATION AND LIABILITIES

Legal Notes and Comment—California. LOUIS H. BURKE & RICHARD CARPENTER. Western City **19:** 2: 38; 3: 42 (Feb., Mar. '43). *Property — Waters — Pueblo Rights — Constit. Art. XIV, Sec. 3.* Actions to quiet title of Los Angeles R. waters and certain ones added thereto including normal river, spread, return and conserved flood waters. Cities of Glendale and Burbank contended, city of Los Angeles, successor to pueblo who had right to take from normal river waters as much water as reasonably necessary for munic. purposes and its inhabitants' use, no longer had such right which had been extinguished by Sec. 3 Art. XIV of State Constitution. *Held:* Rights of city possessing pueblo right, effect of above Sec. 3 and policy thereof, effect of an appropriator spreading waters re capture, abandonment, estoppel, surplus water use, prescriptive rights, etc., discussed in detail. Superior rights of successor of pueblo established. *See* City of Los Angeles *v.* City of Glendale (56 A.C.A. 490 Dec. 31, '42). *Eminent Domain—Compensation—Findings—Elements of Value —Subdivision:* Action to quiet title to easement which, practically, converted into eminent domain proceeding with provision plaintiff should have easement upon ascertainment of compensation and damages by ct. Plaintiff contended trial ct. erroneously based judgment on value of pipeline and erred in admitting evidence as to value of property (a ranch) when subdivided into lots. *Held:* Although trial ct. found water pipeline of certain reasonable value, unlikely it considered same as damage item in view of testimony that damage much greater than amt. of judgment. Although action to quiet title, in sense, converted into eminent domain proceeding, trial ct. not so restricted in its reception of evidence as in strict eminent domain proceeding. Any error in permitting witness to give value in units of lots of specified frontage not prejudicial where tried without jury and judge viewed premises. Market value detd. by taking into acct. highest possible use to which land is or may be put and what purchasers would be willing to offer for it in view of such highest possible use. *See* City of Napa *v.* Navoni (56 A.C.A. 323 Dec. 21, '42). *Taxation—Exemption—Outside Property—Water Dists.—Munic. Corp.—Constitution—Constr.* Plaintiff's action organized pursuant to D.A. 9129, composed of 13 member municipalities and munic. water dist. to recover taxes on its property in defendant county outside dist. Property subject to taxation at time of acquisition by plaintiff. Sole issue whether plaintiff was munic. corp. within meaning of Sec. 1, Art. XIII, State Constitution, exempting from taxation lands owned by counties, cities and counties or munic. corps. except lands located outside boundaries thereof, taxable at time of acquisition. *Held:* Plaintiff is munic. corp. in meaning of above sec. Purpose of permitting tax on munic.-owned property located outside its boundaries to conserve revenues of invaded territories. To hold plaintiff not munic. corp. would permit cities jointly to accomplish what is not permitted individual city. In addn., plaintiff's purposes munic., namely, supplying water for

domestic use within municipalities and in prior proceedings plaintiff alleged itself to be munic. corp. *See* Metropolitan Water Dist. *v.* Riverside. (21 A.C. Feb. 24, '43).—*Ralph E. Noble.*

Legal Notes and Comments—Washington. JOHN A. HOMER. Western City **19:** 2: 38; 3: 42 (Feb., Mar. '43). *Expenditures for Completion of Water System for Using Surplus Water Funds, Not Included in Budget:* May city use surplus water funds to complete water and sewerage system where impracticable to issue more bonds, although no provision made for such expenditure in Budget Law? Budget Law, Sec. 9000–6 Rem. Rev. Stat., authorizes emergency expenditures not provided for in budget: "All emergency expenditures shall be paid for by issuing emergency warrants. Latter shall be paid from any moneys on hand in city or town treasury in fund properly chargeable therewith and such city or town treasurer hereby authorized and directed to pay such warrants therefrom. If at any time insufficient money on hand to pay any emergency warrant, latter shall be registered, bear interest and be called in same manner as other city or town warrants." Act also provides that emergency warrants issued during "preceding fiscal year" shall be included in next budget "sufficient to reimburse all funds from which same paid." Thus, city could provide emergency warrants payable from sewage fund, even though at present no money therein. Warrants remaining unpaid, of course, bear interest. If, however, warrants not accepted to provide money to secure material or work necessary to complete project, futile to issue warrants against any fund. Considered legally possible, in such case, to make loan or advance from surplus of any funds available to Sewer Fund, or fund from which warrants would be payable. This loan or advance then repayable to borrowing source if item and levy for purpose included in next budget. Understood that city may at any time borrow from solvent fund to benefit another solvent fund. *Water Surplus—Sale to Outside Users:* Has city power to discontinue sale of water to customers outside city when it appears that supply becoming insufficient for users within? Gen. rule, municipality has no authority to sell anything except surplus water to users beyond corp. limits. If entire water supply needed for city inhabitants, city's duty and right to refuse to supply outside users.—*Ralph E. Noble.*

Belleville Utilities Case. ANON. W.W. Inf. Exch.—Can. Sec. A.W.W.A. **5:** D: **7:** 35 (Apr. '43). Recent decision by Justice Henderson in action brought by Corp. of City of Belleville to secure: (1) Injunction restraining Belleville Public Utilities Com. from constructing reservoir. (2) Injunction restraining Com. from using surplus moneys derived from operation of water works system for constr. of reservoir until authorized by City Council. (3) Order declaring that bonds and debentures in which Com. had invested surplus funds sole property of Corp. and that Com. has no right, title or interest therein, or right of control of same. (4) Order declaring that all surplus moneys of Com. paid to Corp. sole property of latter. Estd. cost of reservoir desired by Com., $36,000 and bonds and debentures mentioned in (3) amtd. to $15,000. Project had been submitted to and defeated by City Council. Point in issue broadly whether Com., having collected from rates more money than actually needed for operation and maint., could make capital expenditures for addns. to system from such moneys. Justice could find no authority for a pub. util. com. to embark upon constr. of work unless it has money in hand to pay for it or undertaking of munic. council to provide such moneys. Judgment in favor of plaintiff for relief claimed in (1) and (2), but claims (3) and (4) dismissed. In opinion of ct. defendant has right, title and interest in surplus moneys derived from operation of water works system and right to control same to extent of its powers. Com. entitled to credit for surplus funds paid over to City Treasurer as such until Com. has detd. that they are not required for its purposes. Com., however, cannot construct reservoir until authorized by City Council unless it has funds available for such work or undertaking of munic. council to provide such moneys. Other cases referred to in judgment reviewed briefly.—*R. E. Thompson.*

F. A. Graham Gillies, et al. *v.* La Mesa, Lemon Grove and Spring Valley Irrigation District et al. Pub. Util. Fort. (PUR) **46:** 249 (Feb. 18, '43). Plaintiffs are owners of land in El Cajon Valley riparian to San Diego R. Complaint contains 3 counts: (1) Mandatory injunction requiring dist. to furnish and deliver to plaintiffs, on their lands, 3 miner's inches of water at an annual price at charge of $60 per miner's inch. (2) Damages for violation of contract to furnish and deliver water at that price. (3) Declaratory relief.

Plaintiffs alleged water rights, derived from original filing and appropriation in 1885 by El Cajon Rancho for approx. 21,000 miner's inches of flow of the San Diego R. These rights assigned to San Diego Flume Co. which contracted to supply water to lands at price of $60 per miner's inch per yr. In '10, Flume Co. sold all rights to the Cuyamaca Water Co. which assumed obligations. In '25, Railroad Com. authorized sale by Cuyamaca Water Co. of water system and plant and major portion of utility properties to Irrigation Dist. upon condition that Dist. continue to serve quants. of water to which consumers entitled at date of sale. Cuyamaca Water Co. allegedly became pub. util. subject to jurisdiction of Railroad Com. which fixed rates and charges higher than those established in contract with Flume Co. against protest and objection of property owner. Plaintiffs contend that Dist. has refused to deliver water in the amt. and at rates established by the Flume Co. contract. Court ruled to effect that: (1) Landowner not entitled to mandatory injunction requiring Irrigation Dist. to deliver water to his land at contract price after Com. has ordered establishment of higher rates. (2) Violation of terms of contract fixing rates for water service can furnish no grounds for action for damages when rates fixed by contract superseded by rates established by Com. (3) Customer not entitled to declaratory relief by way of a detn. of rights under a contract fixing rates for service when rates so fixed superseded by orders of Com.—*H. J. Chapton.*

The War, the Supreme Court and Lake Michigan's Water Level. ANON. Am. City **58:** 5: 52 (May '42). Legal action against diversion of Lake Mich. water into Chicago R. began in '22 and ended in U.S. Supreme Court in '30. Decision reduced diversion from 10,000 to 1500 cfs. within 8 yr., during which time sewage treatment facilities along river built. Such facilities not completed before outbreak of war, resulting in sludge banks and odor difficulties. In addn., reduced diversion increased poln. of lake at Calumet water supply intake; curtailed generation of power at Sanitary District's Lakeport generators to 45% of capac. and reduced eff. of river transportation. Appeals to increase diversion to 8500 cfs. made to Supreme Court and President in '40 failed. Greater contribution to war effort at Chicago could be realized by increasing the flow; inflexibility of law has so far prevented it.—*F. J. Maier.*

Water Hearing Stopped. ANON. Pub. Util. Fort. **31:** 850 (June 24, '43). Further unrestricted purchases of water companies by munic. authorities in Pa. ceased on May 27, as Gov. Martin signed Becker-Dent bill which makes mandatory state pub. util. com. approval of such deals. Measure passed in time to govern proposed purchase of Pennsylvania Water Co. by Borough of Wilkinsburg and purchase of Suburban Water Co. by the Borough of Oakmont, which deals had been protested bitterly by neighboring municipalities. Did not, however, affect purchases previously consummated. Act resulted from investigation by special senate committee into activities of the Westmoreland County Authority.—*H. J. Chapton.*

Capture by Enemy Not a Bar to Order to Dispose of Subsidiary. Re *Driscoll et al., as Trustees of Associated Gas & Electric Corp.* ANON. Pub. Util. Fort. **31:** 260 (Feb. 18, '43). If Japanese do not dispose of properties in Philippine Islands constituting part of Assoc. Gas & Electric (AGE) system, trustees of AGE must dispose of them in compliance with §11(b)(1) of Holding Co. Act. AGE suggested impossibility of disposing of interest in captured properties within time allotted by §11(c) of Act, also contended that it was intention of Congress that compliance under act apply only when practicably possible to accomplish disposition. Com. referred to ruling in previous case, that difficulties of disposition had no bearing on whether any particular interest retainable. Com. concluded that as trustees could not dispose of properties at present on proper basis extension of time would be granted; also, as long as present condition existed, would not apply to courts for enforcement.—*H. J. Chapton.*

Wisconsin Public Service Commission. *Irma Schoeder et al.* v. *City of Wisconsin Rapids.* Pub. Util. Fort. (PUR) **46:** 24 (Feb. 18, '43). Investigation on complaint of alleged illegal activities of munic. officers operating munic. plants. Com. rules: Jurisdiction of Com. to investigate alleged illegal activities of munic. officers managing and operating munic. elec. and water utils. limited to neglect or violation of util. statutes which it administers. Complainants in effect asked that Com. institute *quo warranto* proceedings which Com. stated was matter for courts. Com. also stated that if City of Wisconsin Rapids or any of its citizens believed that

laws of state violated, city or citizens had ample remedies in court for such situation.—*H. J. Chapton.*

Wisconsin Supreme Court. *City of Milwaukee* v. *Public Service Commission et al.* (Wis.—, 4 N.W. (2d) 800). ANON. Pub. Util. Fort. (PUR) **46:** 287 (Mar. 4, '43). By order of Com., plaintiff City of Milwaukee required to extend water service in Town of Milwaukee. Plaintiff denied jurisdiction of Com. to compel extension, claiming costs and difficulty of furnishing service to be out of proportion to needs for service and rate ordered would occasion loss to plaintiff and burden upon customers. Appeal from judgment dismissing municipality's action against Com. requiring it to extend utility service to adjoining towns; reversed. *Decisions:* (1) Munic. util. which extends service beyond corporate limits becomes util. outside city limits to extent of its holding out as such, and the geographical scope of holding out must be measured by terms and limitations of contract with town by which service extended. (2) Munic. util. which by contract with adjoining town served small, isolated and precisely limited portion of the town did not become utility in town as whole so as to be bound to extend service to whole town pursuant to Com. order, notwithstanding that even if contract canceled, munic. plant would be compelled to continue to serve contract customers upon util. basis. (3) Resolution of city council to induce outlying communities to drop support of proposed metropolitan water dist. if city would extend service to portions of towns that had shown intention to become annexed to city, or in individual cases, according to merits of case, did not evidence intention of city to extend service into towns as a whole so as to be bound to do so pursuant to Com. order. (4) Munic. plant which is in no position to keep other utilities out of town upon any claim to indeterminate franchise does not have duty to extend service in town beyond limits of its holding out evidenced by its contract with town, and when holding out not co-extensive with limits of town, it cannot be treated as util. in town as a whole.—*H. J. Chapton.*

Notice Not Required When Service Denied for Missappropriation of Current. Pub. Util. Fort. **31:** 854 (June 24, '43). Judgment in favor of elec. customer for statutory penalties based on discontinuance of service without notice reversed by appellate div. of New York Supreme Court, which held that controlling statute does not require notice where consumer missappropriated current by tampering with meter, etc.—*H. J. Chapton.*

Water Pollution Control. C. E. BEALS. Neb. Munic. Review. *No.* 223: 8 (Feb. '43). Bill H.R. 98, introduced in House of Representatives Jan. 7, '43 to create div. of water poln. control in U.S. Pub. Health Service. Provides for grants and loans for treatment plants, also authority that after 3 yr. from date act effective, will be duty of U.S. Dist. Atty. in judicial dist. containing nuisance, to bring action for abatement thereof. Such action by U.S., however, shall not limit any person's rights to bring action for damage caused by poln. of any water or for abatement thereof.—*Ralph E. Noble.*

Order of State Stream Control Commission to Construct Sewage Treatment Plant Upheld. *Court Decision on Public Health.* Pub. Health Rpts. **58:** 1198 (July 30, '43). *Case:* Mich. Supreme Ct.; *People* ex rel. *Stream Control Comm.* v. *City of Port Huron* et al. (9 N.W. 2d 41; Apr. 6, '43). Mich. Stream Control Com. ordered Port Huron to construct sewage treatment plant for city sewage treatment before discharge into state waters. City failing to comply, Com. brought proceeding to enforce order and restrain city from discharging sewage into Black and St. Clair Rivers. After lower ct. held for city, appeal made to State Supreme Ct. Latter held that there was sufficient evidence to support contention that present raw sewage disposal method constant menace to health and well being thus justifying com.'s order; also that it was no defense to statutory charge of river poln. that others contributed or contributing thereto. Doctrine of comparative injury, city's financial inability to comply, war conditions affecting constr. supplies and time element discussed.—*Ralph E. Noble.*

Suit Brought to Enforce Water Supply Chlorination Order. ANON. N.H. Health News **20:** 13 (Sept. '42). Suit for recovery of $15,000 filed by office of Conn. Atty.-Gen. against water comrs. of Charleston Water Precinct because of their failure to carry out order of State Board of Health directing installation of chlorination of village water supply, brook source on which inspections showed hazard of contamn. Order made

under authority of Sec. 19a of Chap. 141, Public Laws (Chap. 166, Rev. Laws), which pertains to source, treatment and distr. of all public water supplies for domestic use. Provides for investigation by board and, after public hearing, fixing of requirements for treatment or other improvement. Failure to carry out such order after 20 days (which includes 10 days for appeal) subjects municipality, corporation, officer or board so failing to fine of from $100 to $1000 for each day of failure to comply.—*P.H.E.A.*

Liability of State Officials for Failure to Furnish Safe Drinking Water to State Institution. *Court Decision on Public Health.* Pub. Health Rpts. **58:** 1230 (Aug. 8, '43). *Case:* U.S. Circuit Ct. of Appeals, 7th Circuit; *People of Illinois, for use of Chicago Trust Co.* et al. v. *Maryland Casualty Co.* et al.; *Maryland Casualty Co.* et al. v. *Bowen* et al. (132 F. 2d 850; Dec. 9, '42). Actions brought against sureties to recover upon official bonds of certain Ill. state officers for death of and injuries to certain persons from typhoid fever allegedly resulting from contamd. water at Ill. mental hospital. Deceased and injured persons not inmates but employed at constr. on premises. Officers involved: director and asst. director of pub. welfare; director of public health; and hospital mgr. Neither officers nor depts. sued but defendant-sureties as third party plaintiffs filed against officers as third party defendants, to hold officers personally liable if their official bonds breached. Officers moved to dismiss original and third party complaint, and trial ct. entered order dismissing both. On appeal to U.S. Circuit Ct. of Appeals question whether such officers liable for alleged negligent, wanton and wilful failure to supply safe drinking water at hospital. Plaintiffs contended it officers' duty to cause safe water to be supplied thereto, stemming from Ill. statutes creating pub. health and welfare depts. and their officers. Statute provided no specific duty to supply safe drinking water at hospital. Appellate Ct. held that state, by statute defining officers' powers and duties, not creating latter as owing to individuals who might constitute gen. pub. of state; merely outlined state's assumed pub. duty. Thus officers considered liable only to state, not to individuals in instant-case; consequently, officers not liable to plaintiffs for their conduct; therefore, there could be no action by plaintiffs upon officers' official bonds. *Ralph E. Noble.*

Amebic Dysentery. *Court Decision on Health.* Pub. Health Rpts. **58:** 246 (Feb. 5, '43). Addnl. compensation under workmen's compensation act for employer's serious and willful misconduct and violation of health statute by employer subject of suit (Calif. Sup. Ct.; *Parkhurst* v. *Indus. Accident Com.* et al.; 129 P. 2d 113; decided Sept. 24, '42). In course of employment, iron worker contracted amebic dysentery through drinking water supplied. State indus. com. awarded him compensation but denied addnl. award claimed for employer's alleged serious and willful misconduct. Developed fact water supplied men by open bucket and common dipper, violating statutes requiring closed containers and individual drinking cups. Supreme Ct. held it long recognized that communicable diseases readily transmitted by common drinking cups and statutes in present case designed to safeguard employees. Violation of same particularly serious when hundreds of men employed on same project simultaneously and without access to other drinking water; not mere negligence but criminal conduct punishable as misdemeanor. Employer charged with knowledge of statute and found by com. to know water distributed in violation thereof. Order denying addnl. compensation annulled.—*Ralph E. Noble.*

Typhoid Fever—Workmen's Compensation Act—Held to Arise out of Employment. (Ill. *Supreme Ct.; Permanent Constr. Co.* v. *Industrial Commission* et al. (2 cases), 43 N.E. (2d) 557; decided June 11, '42, as modified on denial of rehearing Sept. 15, '42). Pub. Health Rpts. **58:** 374 (Feb. 26, '43). In 2 cases before Ill. Sup. Ct., question involved whether typhoid fever, contracted by 2 constr. co. employees, arose out of their employment within meaning of state workmen's compensation act. They worked on state hospital grounds where drinking water available from water works system maintd. by state for use on premises. Gen. supply became contamd. and typhoid epidemic occurred. Above 2 employees contracted disease from water taken from hydrants to them in buckets. Arbitrator and State Indus. Com. found that in this manner, two employees suffered accidental injuries in course of their employment. Finding, however, does not det. whether injury arose out of employment. Subject further elaborated by ct. Then concluded by latter holding that employees drinking typhoid bacilli-contamd. water during employment

hours, supplied them by employer, received accidental injuries arising out of, and in course of, employment.—*Ralph E. Noble.*

Typhoid Fever Held to Be Accidental Injury Under Workmen's Compensation Law. *Court Decision on Public Health.* Pub. Health Rpts. **58:** 1030 (July 2, '43). *Case:* Md. Ct. of Appeals; *Union Mining Co.* et al. v. *Blank* (28 A. 2d 568; Oct. 29, '42). Employee contracted typhoid fever through drinking water supplied him by employer. Latter provided laborer with buckets and dippers to bring water at employer's expense from spring 400'–500' from place employed. Spring used with apparent immunity by community 100 yr. State Ct. of Appeals had to det. whether infection accidental in terms of compensation statute. Appellate Ct. found instant case showed typhoid fever acquisition by employee accidental. Finding typhoid bacteria in the water clearly unexpected and employee had no reason to suppose present. Injury was infection or ulceration of intestines by bacilli arising out of and in course of employment because water drunk by employee while working and supplied him by employer as part of working conditions.—*Ralph E. Noble.*

LABORATORY CONTROL—EQUIPMENT AND APPARATUS

Determination of the Precision of Analytical Control Methods. RAYMOND F. MORAN. Ind. Eng. Chem.—Anal Ed. **15:** 361 (June '43). Precision of anal. control methods may be established by statistical reasoning based on the std. deviation. Method tested first, from single large stock sample, under ideal conditions, to det. highest precision. From 10 such anals. calc. arithmetical avg. $\bar{X}_1$, std. deviation, $\sigma_{10} = \sqrt{\frac{\Sigma d^2}{n}}$ (d = individual deviation from avg.; n = no. of samples), limit of uncertainty of avg. $LU_{\text{avg.}} = \bar{X}_1 \pm \frac{3\sigma_{10}}{\sqrt{10}}$, and limit of uncertainty under best conditions $LU_1 = \pm \frac{3\sigma_{10}}{0.923}$. If this precision considered satisfactory, lab. tests for year follow to discover variability under routine conditions. Using 2 determinations per mo., calc. limit of uncertainty of avg. $LU_{\text{avg.}} = \frac{3\sigma_{24}}{\sqrt{24}}$, and limit of uncertainty of the method $LU_2 = \pm \frac{3\sigma_{24}}{0.968}$. If limit of uncertainty of avg., LU_2, includes known value and is small enough, method regarded as sufficiently accurate for routine adoption. Comparison of LU_2 with LU_1 measures possible improvement in routine work. From study of 40 basic anal. methods LU_2/LU_1 ratios of 1.0–1.5 indicate variations mainly from instrumentation; 1.5–2.5, normal relationship; over 2.5 show personal and seasonal variations, reducible without basic revision of method. Duplicate results do not reduce std. deviation by theoretical amt. as anals. not truly random.—*A. A. Hirsch.*

Automatic Medium Dispenser for the Bacteriological Laboratory. HOWARD NECHAMKIN. Chem. Analyst **32:** 1: 20 (Feb. '43). Wide-mouth bottle of convenient size (250–500 ml.) fitted with 3-hole stopper: one hole carrying thermometer; second, capillary tube bent in form of **L** and having at outer end rubber bulb with compression valve; and third, 15-ml. pipet cut off just below bulb and graduated at capac. of 10 ml., projecting part being bent slightly and drawn out to form nozzle. App. partly filled with medium, bulb squeezed to fill pipet to graduation, bottle inverted and bulb again squeezed to force medium in pipet into receiving tube or petri dish. If desired, app. and contents may be sterilized in autoclave.—*R. E. Thompson.*

Delivery of Liquids at Low and Constant Rates. E. C. PAGE & J. C. WHITWELL. Ind. Eng. Chem.—Anal. Ed. **15:** 435 (July '43). App. relies upon controlled rate of vaporization as method of regulation. Liquid boiled off at desired rate in Dewar flask and condensate fed into one arm of **U**-tube thereby displacing liquid to be delivered from other arm. Tube sealed at bottom by some heavy liquid such as carbon tetrachloride. Wick in discharge spout elims. hold-up due to surface tension. Rates for app. described vary from 0.7 to 2 ml. per min. Hydrostatics formulated.—*A. A. Hirsch.*

An Improved Salt Bridge for Polarographic and Potentiometric Measurements. DAVID N. HUME & WALTER E. HARRIS. Ind. Eng. Chem.—Anal. Ed. **15:** 465 (July '43). Attached to calomel half-cell is ordinary soft rubber tubing filled with satd. potassium

chloride soln.; this terminates in short glass tube filled with 3% agar gel, also satd. with potassium chloride, immersed in electrode vessel. If potassium chloride contact undesirable, first agar plug may communicate into another agar plugged glass tube contg. liquid of same compn. as in cell.—*A. A. Hirsch.*

Microscope Eyepiece Pointer. H. WHITTAKER. Pop. Sci. **142:** 5: 188 (May '43). Easily attached eyepiece pointer used for indicating specimen. Cut straight black hair slightly longer than half diam. of ocular. Next, apply drop of Canada balsam to upper surface of diaphragm. Place hair in cement, making certain it lies flat and points to center of aperture. Trim hair just short of center.—*Ralph E. Noble.*

Removal of Glass Rods or Tubes From Rubber Stoppers. HENRY M. BURLAGE. Chem. Analyst **32:** 1: 17 ('43). Present shortage necessitates conservation of rubber in lab. Waste of rubber stoppers in which short pieces of glass tubing or rod broken off common. Many workers throw stopper away. Practice of removing glass by cutting stopper in some cases makes it useless. Such pieces of glass easily removed without injury either to worker or stopper by selecting cork borer which *just* slides over tubing or rod, i.e., id. of borer slightly greater than that of glass. Then glass can be sepd. from stopper by manipulating borer in usual manner.—*Ed.*

A Spot Plate for Drop Tests. PHILIP W. WEST. Ind. Eng. Chem.—Anal. Ed. **15:** 47 (July '43). Combination black and white spot plate, produced by black-glazing half width of ordinary spot plate, useful for observing formation of either colors or precipitates, light or dark.—*A. A. Hirsch.*

A Simple Improvement of the Imhoff Cone. H. L. OLIN & E. M. MYERS. Chem. Analyst **32:** 1: 22 (Feb. '43). Stiff sediments forming in tip of Imhoff cones may be readily removed through stopcock fused to bottom.—*A. A. Hirsch.*

Ultraviolet Photometer for Analysis of Solutions. IRVING M. KLOTZ. Ind. Eng. Chem.—Anal. Ed. **15:** 277 (Apr. '43). Simple ultraviolet photometer for anal. of solns. that absorb light of 2537 Å from germicidal lamp described. Since Beer's law inapplicable, calibration chart of log I_0/I constructed for several compds., including phenol in water.—*A. A. Hirsch.*

Sample of Water From Deep Well Obtained in Weighted Bottle. ANON. Pop. Mechanics **79:** 3: 106 (Mar. '43). Bottle corked lightly, long cord tied to cork then around bottle neck and finally to fish-line sinker. Arrangement prevents water near top of well from entering bottle being lowered. Firm jerk on line withdraws cork, allowing bottle to fill and be raised.—*Ralph E. Noble.*

CHEMICAL ANALYSIS

The Electrochemical Determination of Dissolved Oxygen in Water. FRITZ TÖDT. Gesundh. Ing. (Ger.) **65:** 76 ('42); Chem. Zentr. (Ger.) **I:** 3242 ('42). Suitable metallic pairs (Pt and Cd alloys) give definite residual current dependent on amt. of O reaching noble metal electrode. Current can be used as measure of O content. In unstirred solns., salt concn. without influence. In strongly stirred solns., more O reaches electrode, current larger and depends on salt concn. Decrease of O content with time in sulfite solns. can be detd.—*C.A.*

Determination of Available Chlorine in Solutions Containing Textone ($NaClO_2$). JAMES F. WHITE. Am. Dyestuff Rptr. **31:** 484 ('42). Discussion of following: (1) detn. of total available chlorine including chlorite, hypochlorite and ClO_2 by means of KI and $Na_2S_2O_3$; (2) detn. of hypochlorite by means of arsenite-iodine (As_2O_3-I_2); (3) detn. of total oxidizing power including chlorate by Wagner modification of Ditz method with std. $Na_2S_2O_3$; (4) detn. of chloride with $AgNO_3$; (5) detn. of ClO_2 by means of $Na_2S_2O_3$; (6) acidity or alkalinity; and (7) calcns.—*C.A.*

Turbidimetric Determination of Small Amounts of Chlorides. E. N. LUCE, E. C. DENICE & F. E. AKERLUND. Ind. Eng. Chem.—Anal. Ed. **15:** 365 (June '43). Hellige turbidimeter, combining principles of turbidimetry and nephelometry, used to det. up to 250 μg. chloride, requiring less than 15 min. working time per detn. Adjust pH to phenolphthalein neutrality, dil. with distd. water to 20 ml., add 20 ml. of abs. ethanol; solu-

should remain clear. While swirling, drip in 5 ml. of nitric acid-silver nitrate reagent (12.5 ml. concd. nitric acid and 1.70 g. silver nitrate per liter). Make up to mark in 50-ml. flask with abs. ethanol, shake. Digest at 40°C. for 30 min., cool, pour into 20-mm. optical cell, and 10 ml. abs. ethanol; read as soon as bubble formation ceases, but no later than 30 min., obtain chloride concn. from calibration curves prepd. by same procedure. No filter used above 2 ppm., milk glass between 1 and 2 ppm. and gray glass filter below 1 ppm. chloride. Alcohol stabilizes suspension and reduces opalescence. Addn. of pure electrolytes to stds. equiv. to dissolved salt in sample usually unnecessary. Acetic acid may be substituted for alcohol.—*A. A. Hirsch.*

A Method, Using Mercury, of Determining Chlorides in Drinking Water Containing Little Mineral Matter. L. N. LAPIN & W. P. MOROS. Zavodskaya Lab. (U.S.S.R.) **9:** 1247 ('40); Chem. Zbl. (Ger.) **1:** 2444 ('42). Authors developed method of detg. small amts. of chloride in water. Following conclusions drawn: (1) in titration of sample of water with mercuric nitrate, indicator recommended diphenylcarbazide or diphenylcarbazone (according to Dubsky and Trtilek); (2) addn. of alcohol to water makes color change at end of titration more definite and 0.0005 *N* soln. of mercuric nitrate can be used; and (3) titration as carried out by authors more accurate than usual iodometric method and is equivalent to the nephelometric method.—*W.P.R.*

Conditions for the Rational Utilization of Potassium Chromate and Arsenate as Indicators in Titrating Chlorides According to Mohr. N. A. TANANAEV & I. A. PESHKOV. J. Applied Chem. (U.S.S.R.) **15:** 223 ('42). Authors detd. relation between titration error and concn. of K_2CrO_4, which is detd. by equil. const. of reaction: $Ag_2CrO_4 + 2Cl^- \rightarrow 2AgCl + CrO_4^{=}$, used in Cl anal. This concn., which is calcd. as 1.5×10^{-2} mol/l., wholly confirmed by expt. Solns. at pH 3 to 10.5 can be titrated directly after addn. of indicator, but solns. of higher and lower pH values must be appropriately neutralized; acid solns. to methyl orange, alk. solns. to phenolphthalein. Sodium arsenate, both from theoretical and exptl. data, not suitable for Mohr titration. Final concn. of indicator should be 1.5×10^{-2} mol/l.—*C.A.*

A Colorimetric Method for the Determination of Sodium. ERIC A. ARNOLD & ALFRED R. PRAY. Ind. Eng. Chem.—Anal. Ed. **15:** 294 (Apr. '43). Triple acetate $MaZn(UO_2)_3(C_2H_3O_2)_9.6\,H_2O$ pptd. by either Barber and Kolthoff or Caley and Foulk procedure, then dissolved in excess of ammonium carbonate, and hydrogen peroxide added to develop an orange to red color, depending on the uranyl ion concn. 5200-Å wave-length chosen for transmittance measurements.—*A. A. Hirsch.*

Determination of Sodium in the Presence of Molybdenum. C. H. HALE. Ind. Eng. Chem.—Anal. Ed. **15:** 516 (Aug. '43). Molybdenum interferes in zinc uranyl acetate method for sodium by forming yellow, amorphous ppt. Addn. of citric or tartaric acid elims. interference by forming soluble complex with oxidized Mo.—*A. A. Hirsch.*

Determination of Fluorine in Organic Compounds With Cerous Nitrate. M. L. NICHOLS & J. S. OLSEN. Ind. Eng. Chem.—Anal. Ed. **15:** 342 (May '43). After decompn. of org. compd. by sodium peroxide in a nickel Parr microbomb, fluoride titrated with cerous nitrate, using glass electrode or visually with methyl red indicator. Alternate procedure suggested when sulfate present. Literature reviewed; 61 refs.—*A. A. Hirsch.*

Stage Photometric Determination of Magnesium in Water. ANON. Chem. Ztg. (Ger.) **66:** 207 ('42). Describes modification of Müller's method for detg. magnesium colorimetrically by means of Titan yellow, for use with softened water. For this method, softened water should contain at least 5 mg. calcium ions (17 mg. calcium sulfate) in 50 ml. For detn., 50 ml. water acidified with 1 drop concd. sulfuric acid, then treated with 10 ml. of 1% soln. of starch; 5 ml. of 0.05% soln. of Titan yellow and 8 ml. 2*N* sodium hydroxide added and mixt. made up to 100 ml. After 10 min., color developed compared photometrically with color developed in soln. contg. same amts. of starch, Titan yellow and sodium hydroxide in distd. water. Mn estd. graphically from color developed.—*W.P.R.*

Microdetermination of Magnesium With the Polarograph. CHRISTOPHER CARRUTHERS. Ind. Eng. Chem.—Anal. Ed. **15:** 412 (June '43). Procedure for detg. microquants. of Mn as hydroxyquinolate.—*A. A. Hirsch.*

Accurate Determination of Free Carbonic Acid in Water With the Aid of New Correction Values. SZILARD PAPP. Z. Anal. Chem. (Ger.) **125:** 349 ('43). Free CO_2 usually detd. by titration to phenolphthalein end-point with either NaOH or Na_2CO_3. Some anomalous results traced to error in detn. of end-point. Color change of phenolphthalein takes place at lower pH than corresponds to neutral $CaH_2(CO_3)_2$ so that, in many cases, results obtained by titration much too low. Possible to apply correction, however, so that accurate results can be obtained. Table given, with 80 entries, for making correction. Correction based upon following factors: carbonate hardness of water and 0.1 mg./l. free CO_2 found by titration with Na_2CO_3. With aid of correction and titration with HCl, possible to det. satisfactorily very small quants. free CO_2. —*C.A.*

Extraction and Colorimetric Estimation of Certain Metals as Derivatives of 8-Hydroxyquinoline. THERALD MOELLER. Ind. Eng. Chem.—Anal. Ed. **15:** 346 (May '43). Agitation of aq. solns. with chloroform soln. of 8-hydroxyquinoline enables complete extraction of metallic complexes in following optimum pH ranges: iron, 1.9–3.0; aluminum, 4.3–4.6; bismuth. 4.0–5.2; cobalt, 6.8 or above; nickel, 6.7 or above; and copper 2.7 to at least 7.0. Below these lower limits extraction partial or zero. Extracts contg. 20 mg. of metal per liter follow Beer's law at wave lengths of max. absorption and hence adapted to colorimetric detns.—*A. A. Hirsch.*

Determination of Iron in Water. FRANCIS J. HALLINAN. Ind. & Eng. Chem.—Anal. Ed. **15:** 510 (Aug. '43). To 30-ml. water sample add 20 ml. of 4 *M* hydrochloric acid; heat below boiling for 20 min. After cooling add 1 drop of 0.2 *N* potassium permanganate and 5 ml. of 3 *M* potassium thiocyanate. Compare mixt. immediately with stds. Stable color stds. prepd. from solns. of potassium chloroplatinate, cobaltous chloride and cupric chloride; these mixts. adjusted against controls to secure visual match. Solns. contg. less than 0.4 ppm. iron compared in 50-ml. Nessler tubes; greater concns. up to 4 ppm. matched in 2-oz. French square bottles. Ordinary amts. of org. matter, sodium hexametaphosphate and sodium pyrophosphate do not interfere. Copper interferes by forming thiocyanate which throws color match off hue.—*A. A. Hirsch.*

Nephelometric Determination of the Hardness of Water. A. ROMEO & V. GAMBARDELLA. Chim. Ind. Agr. Biol. (Ital.) **17:** 4 ('41); Chem. Zentr. (Ger.) **I:** 2809 ('42). 50 ml. water contg. 10–50 ppm. total hardne 1 ml. K oleate reagent added. Turbidi compared after 15 min. with stds. K olea reagent prepd. by shaking 7.05 g. oleic ac with soln. of 1.60 g. KOH in 5 ml. H_2O, tra ferring emulsion by means of 50 ml. 70% al to flask, refluxing for 1 hr. and finally dilg. t 250 ml.—*C.A.*

A New Selective Reagent for Lithium. LOCKHART B. ROGERS & EARLE R. CALE Ind. Eng. Chem.—Anal. Ed. **15:** 209 (Ma '43). From solns. as chloride, nitrate, pe chlorate or sulfate, excluding all metals bu alkalis, lithium up to 50 mg. in 1–5 ml. vo quantitatively pptd. under fixed condition described, as complex periodate by reagen contg: potassium hydroxide 24 g.; potassiu metaperiodate, 10 g.; and water, 100 m Ppt. dissolved in dil. sulfuric acid, potassiu iodide added and liberated iodine titrated wi 0.1 *N* thiosulfate soln., or when lithium ex ceeds 10 mg. acid soln. buffered with borax o sodium bicarbonate and liberated iodin titrated with 0.1 *N* sodium arsenite sol Only rapid and accurate method to det. lith ium in presence of sodium.—*A. A. Hirsch.*

Volumetric Determination of Bromide in Brines. HOBART H. WILLARD & ARNO H. A HEYN. Ind. Eng. Chem.—Anal. Ed. **15:** 3 (May '43). Difficulties in detn. of bromide in salt brines contg. much calcium and ma nesium by the van der Meulen method avoide by adjusting pH of hypochlorite oxidizi soln. with acetic acid-sodium acetate buffe from 6.0–6.5 for quant. oxidation of bromid to bromate. Excess hypochlorite removed b formate and bromate titrated iodometrically —*A. A. Hirsch.*

Semimicroanalysis of Saline Soil Solutions. R. F. REITEMEIER. Ind. Eng. Chem.—An Ed. **15:** 393 (June '43). System of adapte photometric and volumetric semimicrometh ods described for limited vols. of soil soln. such as extracted by pressure membran method. Conductivity detd. in 5-ml. cel and pH by "one-drop" glass electrode. Or carbon detd. by chromic acid oxidation; ca cium by pptg. oxalate, centrifugal washin and direct titration in perchloric acid sol with ammonium nexanitrato cerate, usin

nitro-ferroin indicator; magnesium by estg. phosphate content in magnesium ammonium phosphate hexahydrate by ceruleomolybdate reaction; sodium colorimetrically after dissolving sodium uranyl zinc acetate ppt.; potassium, photometrically, from cobalt in cobaltinitrite ppt. with ferrocyanide and choline hydrochloride; carbonate and bicarbonates by the Warder alkalimetric titration to phenolphthalein and methyl orange end-points; chloride by micromodification of Mohr's silver nitrate-potassium chromate method; sulfate by titrating benzidine sulfate ppt. with dil. std. base; and nitrate by reduction, distn. and Nesslerization. Precision and accuracy of each method established.—*A. A. Hirsch.*

Crystalline Compounds Observed in Water Treatment. CARROLL E. IMHOFF & LOHR A. BURKARDT. Ind. Eng. Chem. **35:** 873 (Aug. '43). X-ray powd. diffraction and petrographic microscope supplement chem. anals. to identify mineral forms of cryst. ppts. and deposits encountered in water treatment and in boiler water systems. Using these methods, 38 crystalline species identified to date; conditions for their formation and occurrence in practice discussed. 40 refs.—*A. A. Hirsch.*

BACTERIOLOGY

The Microbe as a Biological System. SELMAN A. WAKSMAN. J. Bact. **45:** 1 (Jan. '43). In dealing with microbes as disease-producing agents or in indus. and foodstuff prepn., many accustomed to concern themselves with pure cultures recognized as *sine qua non* of microbiologist. Pure culture isolation one of fundamentals of Koch's postulates, the 10 commandments of bacteriology. Thus, thinking and available information on subject codified entirely on basis of pure culture studies. This perhaps justifiable or essential when considering microbes as causative agents of disease and methods for combating them. Hardly sufficient, however, in studying natural microbal processes in soil, residual waste of plant and animal life, water basins, sewage disposal plants, and other substrates where activities express *in mixed pops.* Soil enrichment methods demonstrate extensive microbiol. pop. composed of thousands of bact. species, hundreds of fungi, actinomycetes and algae genera and numerous families of protozoa, nematodes, etc. Some organisms have highly specific functions such as N fixation, nitrite production from NH_3, nitrate from nitrite and H_2SO_4 from S. Some processes effected in chain-like reactions where one organism uses or depends upon products or reactions of another as in protein or cellulose decompn. Any attempt to clarify numerous inter-relations composing complex microbiol. pop. must encompass factors based upon: (1) availability and utilization of nutrients, (2) competition for available space, (3) effect of environmental conditions upon specific micro-organisms, (4) relationships among individuals within homogeneous and heterogenous pops., (5) relationships between young, growing and reproducing cells and older respiring cells, (7) relationships between microbes adaptable to symbiotic life and those unadaptable and (8) relationships between parasitic and saprophytic micro-organisms. Collectively, these factors comprise "dynamics of pops." Physiology of organism in pure culture markedly different from same in mixed pop.; behaves quite differently in presence of other organisms. For example, certain bacteria decompose cellulose and fix N vigorously in presence of other bacteria incapable of doing either. Disagreement as to fundamental unity or laws governing metabolism poses questions: (1) Should biochemistry of micro-organisms become study only of changes in matter upon passage through organisms and should life itself comprise active maint. of normal and specific structure? (2) Should metabolism comprise study of numerous enzyme, hormone and vitamin reactions in living system or should these be considered as life manifestations quite apart from individual organism concerned? (3) Should physiology and biochemistry of bacteria be differentiated? (4) What is normal and abnormal metabolism? Some anaerobic bacteria produce butyric acid in presence of $CaCO_3$, but yield largely butyl alc. in absence of neutralizing agent. Antagonism between microbes may be direct or passive, also one-sided or two-sided. When one-sided, only one organism represses another; when two-sided, both repress each other. One-sided antagonism may become two-sided; e.g., *Esch. coli* antagonistic to *Eberthella typhosa;* if latter inoculated into medium earlier than former, however, reverse becomes true. Also suggested there exists, for every bacterium, typical max. pop. level in given

space, at which point multiplication stops without nutrients being exhausted or toxic substances produced. Same true when 2 different bacteria live together. If limiting concns. of 2 organisms different, one with higher value will repress other, but weaker species may check stronger one when planted in sufficient excess. Most interesting antagonistic micro-organism relationships pertain to behavior of pathogenic organisms in contact with native pop. of soils, sewage or water basins. Many organisms now found capable of producing antibiotic substances varying greatly in chem. nature and mech. action, discussed with possible practical applications. [Article forces recognition of existing patterns of influence, broader, deeper and more compelling of result, yet virtually barred from consciousness by habit of thought concerning component characteristics singly, e.g., pH, Cl, alky., temp. etc., rather than integrally.]—*Ralph E. Noble.*

Experiments With Collodion Sacs on Inhibition of Bacterial Growth in Vitro. ALBERT H. HARRIS. J. Bact. **45:** 147 (Feb. '43). In successive expts., small inocula of *Esch. coli* suspended in: (1) synthetic medium; (2) Berkefeld filtrate of *Esch. coli* culture in this medium; (3) dil. thioglycolic acid in medium; and (4) boiled synthetic medium. Each time, suspension introduced into collodion sac in app., permitting periodic change of fresh synthetic medium bathing sac. Growth initiation by even relatively large inocula delayed or prevented when surrounding medium changed at frequent intervals, while prompt in controls. Growth also commenced promptly, despite frequent change of fresh medium, if milieu of original suspension altered in certain ways. Thus, by hitherto unemployed technic, confirmed that phys. properties of medium of surpassing importance. Medium may appear actually bactericidal even when other factors favor growth, if micro-organisms prevented from establishing milieu conditions requisite for growth initiation.—*Ralph E. Noble.*

Bactericidal Enumeration by the Dilution Method. H. W. NORTON. (*Published in abstract only.*) J. Bact. **45:** 20 (Jan. '43). Paper provides tables appropriate to 2-fold diln., enabling detn. of log of concn., and its variance, directly from data without calcn. other than, perhaps, interpolation, using Fisher's method of only counting sterile trials. Tables also provided, giving fiducial limits for concn. for cases in which either all trials fert or all sterile. Theoretical statistical rea given for 2-fold diln. preference.—*Ralph Noble.*

The Mechanism of Adaptation of Bacteri Species to High Temperature. R. R. SPE CER. (*Published in abstract only.*) J. Bac **45:** 99 (Jan. '43). Repeated results follow exposure of 3 species of actively dividing ba teria. (*Streptococcus hemolyticus, Eberthe typhosa* and *Esch. coli*) to high temps. led formulation of 2 biol. generalizations re speci adjustment mechanism: (1) continuous e posure of species to harsh environment may harmless to individual organism, but, in d time, fatal to species; (2) rhythmic exposu of species results in successful adaptation same and to greater intensity of same enviro ment when exposure continuous. First ge eralization shown to hold for species oth than bacteria (paramecia and flat worms subjected to several different environmen (dyes and other chems.).—*Ralph E. Noble.*

The Use of a Substance Extracted Fro Irish Moss as a Substitute for Agar fo Bacteriological Purposes. A. W. WALKER A. A. DAY. (*Published in abstract only.*) Bact. **45:** 20 (Jan. '43). Irish moss produc "Carragar," studied as to its solidifying prop erties in culture media and influence on growt and cultural characteristics of various ba teria. "Carragar" may be substituted fo agar for many purposes. Gel formed, how ever, not as solid as that of agar. Whe firmer gel needed, as for streak plates, dif culty overcome by adding 0.5–0.75% aga Media made with this product inoculated wit no. of organisms representing wide range metabolic requirements. Growth on "Ca ragar" compared favorably with that on aga —*Ralph E. Noble.*

Reclamation of Used Agar. JAMES BRODI & DAVID STIVEN. J. Hyg. (Br.) **42:** 498 (Oc '42; issued Dec. 9, '42). Adaptable to a media not contg. tellurite; procedure follow Used agar autoclaved, bulked and poured in small open dish to ½" depth. When set, cho into ¼" thick fingers and put into 3-l. jar cont sufficient 10–20% alc. to cover 1½ to 2 l. aga Alc. to dissolve dyes. Jar then covered wit "linen scrim" and glass tube, passing throug to bottom, connected to faucet set to di fuse cold water slowly 2 days. Excess wate drained off and washed agar autoclaved, cool

to 55°C., pH adjusted to 7.6 and ox serum in ratio 1 : 20 of melted agar, added to clear. Steam 40 min. Filter through Büchner funnel with paper pulp. Distribute in shallow trays, solidify, chop up and place trays in 55°C. incubator or drying oven between 50° and 80°C. After 24 hr., turn drying agar and replace in oven till dry. Store dried agar in screw-capped jar. To convert reclaimed agar into nutrient, use 25 g./l. of latter. Agar mixed with sufficient water plus nutrients to give 1 l. Mix agar with water, then autoclave to melt. Cool to 55°C., adjusted pH to 7.6, add ox serum 1 : 20 as above. Also add requisite vol. of nutrient at 55°C. and pH 7.6. Steam 40 min., filter hot as described above. At this point, standardize gel strength by Jenkins test, distribute, steam 30 min. 3 consecutive days and store. Stock non-nutrient agar similarly prepd. by using 25 g. reclaimed agar in 500 ml. water and add nutrient later as desired. Essential to do Jenkins test, as different agars vary in stiffness. Wt. recommended found to require min. diln. Not necessary to add new agar to reclaimed product for growing meningococci, gonococci and pneumococci. Reclaimed agar can be reclaimed many times without apparent detriment.—*Ralph E. Noble.*

A Method for the Reclamation of Agar. O. FRAZELLE EDWARDS. Proc. Soc. Exptl. Biol. Med. **51:** 84 ('42). Used agar gel repeatedly frozen and thawed, with certain precautions. At each thawing some water drains out and carries away part of sol. substances.—*C.A.*

The Use of Fibrous Sodium Pectate as a Substitute for Agar in Bacteriological Gels. R. M. MCCREADY, H. S. OWENS & W. D. MACLAY. Science **97:** 428 (May 7, '43). Important to develop agar substitute for bact. use. Authors found satisfactory certain mixed metallic salts of fibrous pectic acid. Fibrous sodium pectate purchasable on market, but more satisfactory if purified by suspending in 60% alc., adjusting pH to 7.5 with NaOH, filtering pectate and drying *in vacuo* at 60°C. In prepg. nutrient gel, 2.5% fibrous pectate added to nutrient broth contg. 2 mg. Ca ion/g. of pectate besides amt. already in broth. Test broth to det. that no ions present to ppt. Ca, as latter ion necessary for gel formation. Complete pectate dispersion effected by heating mixt. above 80°C. Medium sterilized as usual. When prepg. plates for colony counts, thoroughly mix bact. suspension and pectate medium as latter more viscous than agar. Let plates stand 30 min. before inversion and incubation. After autoclaving, pour temp. 45° to 50°C. Medium remeltable in autoclave but each raises gelling temp. 5° to 10°C. Nutrient gels prepd. with sodium calcium pectate show smaller pH changes on sterilization than similar agar gels, while water retention ability slightly better than that of agar. Of 58 organisms tested, including *Esch. coli*, most grow well on pectate media without causing liquefaction. Fact some do may be basis of differentiation. Mold growth not tested by authors.—*Ralph E. Noble.*

Bismuth-Sulfite Plating Medium Prepared With Purified Agar. MARY W. WHEELER & MARION B. COLEMAN. (*Published in abstract only.*) J. Bact. **45:** 521 (May '43). Criteria for satisfactory bismuth-sulfite plating medium for isolating typhoid bacilli and salmonellas are: (1) inhibition of coliform group; (2) development of characteristic black colonies with dark metallic halos; and (3) retention of these 2 properties at least 4 days. Experience in prepg. medium showed need for carefully standardized ingredients. Variable results with different brands of commercial agar and even with different lots of same brand emphasized importance of this particular ingredient. Highly purified agar recently found superior to any commercial agars used previously. Purified agar had better gelling properties than commercial agars and, therefore, usable in lower concn. Medium prepd. with it retained differential properties 6 to 8 days. Agar reclamation from used culture medium practical and eff. way to obtain highly purified product, at same time saving material.—*Ralph E. Noble.*

Bromthymol Blue-Dextrose-Agar Plates as an Aid in Determining the Degree of Filtration of Drinking Water. W. LORENZ. Z. Hyg. Infekt Kr. (Ger.) **123:** 576 ('42). For examg. bact. qual. of drinking water author recommends plating on meat agar contg. bromthymol blue and 1% dextrose and incubating at 37°C. Examples of examn. of ground and surface waters by this means described. Numbers of acid-producing colonies (yellow colonies) which grew on this medium shown to be good indication of san. qual. of water. Presence of more than 10 acid-producing bacteria per ml. indicates that water insufficiently purified.—*W.P.R.*

Selective Media for the Isolation of *Shigella dysenteriae*. R. W. FAIRBROTHER. J. Roy. Army Med. Corps. **80:** 151 (Br.) (Mar. '43). Desoxycholate-citrate medium greatly superior to MacConkey's medium for isolating dysentery bacilli from carrier feces. Results also indicate Wilson and Blair medium superior to MacConkey. No justification for continued use of latter medium in examg. feces for dysentery organisms. Relative value of these media tested for purpose indicated when observation made on no. of men returned from Middle East, giving definite bacillary dysentery history 1 to 3 yr. previously.—*Ralph E. Noble.*

Modified Leifson Media for the Isolation of *Shigella dysenteriae* and Pathogenic Members of the Colon-Typhoid Group. JAMES BRODIE. J. Path. & Bact. (Br.) **54:** 499 (Oct. '42). Enrichment in citrate rosolic taurocholate Lemco broth contg. serum digest as nutrient, followed by plating on solid medium of same nature, highly satisfactory for isolating dysentery bacilli. In addn., method enriches pathogens of colon-typhoid group. Direct plating on solid medium cannot be omitted as occasional pos. thereby fails after enrichment, due to *P. morganii, P. vulgaris* and atypical *Esch. coli.* Medium apparently favors smooth strains and, therefore, may be useful in examg. morbid material. Method does not interfere with prelim. serologic tests by rapid slide procedure. No need to wash muco-pus from dysentery stools before direct plating as inoculum can be heavy, e.g., at least ⅛″ diam. loopful for half plate of 3½″ diam. Although enrichment by method described favors smooth forms, does not render *Salmonella* strains more specific. Employed as semi-solid agar, medium does not cause motile strains to deflagellate. *Shigella sonnei* type isolated from feces 5 times with above medium. Isolated strains grew in C.R.A. enrichment broth and solid medium, yielding smooth colonies only.—*Ralph E. Noble.*

SS Agar for the Isolation of *Eberthella, Salmonella* and *Shigella* Groups From Feces. *Compared With MacConkey and Bismuth Sulfite Agars and Tetrathionate Broth Followed by MacConkey Agar.* MOLLIE MOLLOV, JEANETTE E. WINTER & PHILIP STEINBERG. J. Lab. & Clin. Med. **28:** 1021 (May '43). SS agar excellent culture medium for isolating *Eberthella, Salmonella* and *Shigella* from feces. Gives fine colony definition, provides max. coliform inhibition and facilitates isolating intestinal pathogens when large inoculum used. If one selective, inhibitive, solid medium chosen for isolating all intestinal pathogens, SS agar seems best choice thus far. With SS agar, tetrathionate broth of definite value in isolating *Eberthella, Salmonella* and a few *Shigella* organisms. In small series of pos. cases, SS agar found as eff. or superior to bismuth sulfite agar for isolating *Eberthella typhosa* from feces.—*Ralph E. Noble.*

Selective Media for Organisms of the *Salmonella* Group. R. KNOX, P. F. H. GELL & M. R. POLLOCK. J. Path. & Bact. **54:** 469 (Oct. '42). Satisfactory comparison of media for isolation of intestinal pathogens must take acct. of following factors: stage of illness; season, for more non-pathogenic organisms seem to grow in tetrathionate broth in summer months; size of inoculum, for optimal inoculum into tetrathionate sometimes heavy and sometimes light; length of incubation of tetrathionate medium; and kind of medium used for plating from tetrathionate. From present extensive trial 2 facts emerged clearly, i.e., great inferiority of MacConkey's medium to selective solid media now available and to tetrathionate enrichment method, and importance of using selective medium rather than MacConkey for plating out from tetrathionate, to elim. *Proteus* and non-pathogenic non-lactose-fermenters. *Wilson & Blair's medium (WB):* No signif. difference noted between "Difco" dried product and Tabet's modification. While admitting it gives excellent differentiation, authors do not greatly favor WB for following reasons: slide-agglutination of colonies may be unsatisfactory; colonies if crowded, may give atypical appearances; some strains of *Eberthella typhosa* and occasional salmonellas may not grow on it; plates deteriorate rapidly, especially for detection of *Eberthella typhosa;* growth often slow; for indirect plating of *Salmonella schottmueller* pathogen sometimes missed or growth confluent and unrecognizable. In large series of specimens examd. for *Salmonella schottmueller* WB gave twice as many positives as MacConkey, and about same no. as EBG media, but results of latter available after 18–24 hr. *Eosin-Brilliant-Green (EBG):* This medium rapid, selective and gave good slide-agglutination. Standardization of medium troublesome and differentiation only fair. *Eosin-Brilliant-Green-Methylene-Blue (EGBMB):* Addn. of methylene blue to EBG greatly improves differentiation and gives sharp contrast between lactose- and non-lactose-ferementers. Growth

of pathogens good and *Proteus* suppressed. *Pseudomonas* grows, but easily recognized. Detailed formula given, but optimum concn. of dyes varies with different batches and must be gaged by actual trial. *Tetrathionate Agar:* This medium simple to prep. and gives const. results if thiosulfate and iodine solns. accurately made up. Differentiation fairly good and selective growth of some *Salmonella* and typhoid strains better than on brilliant green media. Both for direct and indirect plating has given results as good as any other medium, but recommended that EBGMB also be used for indirect plating, since certain strains will grow on 1 medium and not on other. Tetrathionate agar does not suppress *Proteus morganii*. *Tetrathionate Broth:* Formula used approxd. that of Muller but contained half amt. of chalk and 25% less thiosulfate. Not one of paratyphoid B or salmonella cases detected would have been missed if tetrathionate enrichment method alone used. For *Eberthella typhosa* direct plating also necessary. Tetrathionate broth more successful than brilliant green peptone water. Following routine technique recommended for isolation of intestinal pathogens from feces. Loopful of thick broth suspension plated on MacConkey, EBGMB and tetrathionate agar plates, and 0.25 ml. inoculated into 10 ml. tetrationate broth from which light inoculum plated 18–24 hr. later on EBGMB and tetrathionate plates. With urine, 2 ml. put into 10 ml. tetrathionate broth and same routine followed. This technique gave good results with *Salmonella schottmuelleri* and *Salmonellas* and moderately good results with *Eberthella typhosa* for which it is wise to place also directly on WB medium. For known cases and carriers of paratyphoid B bacilla tetrathionate method alone will suffice. Hynes (*see* Jour. A.W.W.A. **35:** 643 ('43)) included in his study desoxycholate-citrate medium modified from Leifson's formula, but did not use brilliant green or tetrathionate agar media. Would now appear necessary to compare efficacy of these media and also those described by Brodie for dysentery group which may be effective also for other intestinal pathogens.—*B.H.*

A Comparative Study of the Nutritional Requirements of *Eberthella typhosa, Salmonella pullorum* and *Shigella gallinarum*. EDWIN A. JOHNSON & LEO F. RETTGER. J. Bact. **45:** 127 (Feb. '43). 45 strains of *Salmonella pullorum*, 22 of *Shigella gallinarum* and 9 of *Eberthella typhosa* examd. for vitamin, tryptophane and glucose requirements in a chemically defined basal medium of 16 amino-acids, with added thioglycolic acid. *S. pullorum* most variable of 3 species. Only 2 strains demanded nicotinic acid or its amide. Most strains required glucose; some indifferent; and few near borderline. Glucose definitely stimulative in all cases. Response to amino-acids much more variable among strains of this species than in other two. Observations indicate different *Salmonella pullorum* strains vary in vigor and ability to utilize nutritionally important substances. *Eberthella typhosa* and *Shigella gallinarum* have fairly definite requirements and more vigorous in growth-producing abilities than *Salmonella pullorum*. *Shigella gallinarum* only organism of 3 showing definite accessory growth factor requirement, all 22 strains demanding vitamin B_1 for growth. Glucose found non-essential. 8 *Shigella gallinarum* required incubation in 10% CO_2 atmosphere while *Eberthella typhosa* and *Salmonella pullorum* strains needed none. Tryptophane unnecessary for *Salmonella pullorum* and *Shigella gallinarum* while *Eberthella typhosa* required it. Cp. (synthetic, when possible) amino-acids, etc., essential in chemically defined medium.—*Ralph E. Noble.*

Hyodesoxycholic Acid Media for the Estimation and Enumeration of Coliform Bacteria in Milk and Water. EINAR LEIFSON. (*Published in abstract only.*) J. Bact. **45:** 45 (Jan. '43). Various available bile acids studied for their effect on bact. growth and suitability in differential media. Acids tested: desoxycholic, apocholic, hyodesoxycholic, cholic, dehydrodesoxycholic and lithocholic. Latter and dehydrodesoxycholic acids show little inhibitory effect on Gram-pos. bact. growth and are unsuitable. Apocholic behaves much like desoxycholic. 3 other inhibit Gram-pos. bact. growth, and are, in order of decreasing inhibitive capac., desoxycholic, hyodesoxycholic and cholic. Inhibition of coliform growth apparently only quantitative as in counting colonies. For such work, Na hyodesoxycholate most suitable, allowing greatest no. to develop, with complete suppression of Gram-pos. flora and representative members of genus *Aerobacillus*. Both liq. and agar media developed with Na hyodesoxycholate, having provisional formula: peptone, 1%; lactose, 1%; Na hyodesoxycholate, 0.1%; pH 6.7 to 6.9. To agar medium added 1/50,000 neutral red. Coliform colonies in agar medium similar to those in desoxycholate agar. In liq. medium, coliform bacteria produce gas rapidly and abundantly. —*Ralph E. Noble.*

Comparative Study of the Presumptive and Confirmative Media for Bacteria of the Coliform Group and for Fecal Streptococci. A. A. HAJNA & C. ALFRED PERRY. Am. J. Pub. Health **33:** 550 (May '43). Report made on studies to improve selectivity of media for the coliform group and for *Esch. coli.* In first study, eff. of confirmation of coliform organisms from primary lactose broth tubes detd., comparing E.M.B. streak plates and B.G.B. broth tubes. Results obtained confirmed those of other investigators, simpler B.G.B. method giving less than 1% fewer "positives" than far more involved plate confirmation method. Neither method efficient for isolation of *Esch. coli.* Second study made to secure data on eff. of simple secondary tube confirmation for *Esch. coli;* involved transferring 3-mm. loopful of culture from primary lactose broth tube to secondary tube of buffered lactose broth at 45.5°C. Method yielded more than 11% less positives for *Esch. coli* than primary inoculation into modified Eijkman medium, but simplicity may make use desirable under certain circumstances. Study of lauryl sulfate tryptose broth confirmed results of other reports; 78% of lauryl sulfate media tubes that showed gas confirmed (water from 127 samples) for coliform group, whereas only 51.6% of lactose broth tubes with gas, on same samples, confirmed positive. Percentage of false presumptive gas tubes in (1) std. lactose broth and (2) lauryl sulfate tryptose broth as follows for water from: treated tap water, (1) 70%, (2) 9.1%; untreated tap water, (1) 48.6%, (2) 24.9%; untreated well and spring water, (1) 6.5%, (2) 24.5%. Authors' new media a buffered lactose broth containing Bacto bile salts No. 3, found to be a satisfactory selective media for coliform bacteria in limited no. of tests. Found also to be inhibitive to fecal streptococci. In 147 samples, new media, called "EC" (i.e., *Esch. coli*), 100% specific as a primary medium; that is, every primary gas tube was confirmed. Used as secondary confirmatory media, no. of positives obtained was same regardless of whether primary inoculation into lactose broth or "EC" media. In limited series of tests, "EC" broth and lauryl sulfate tryptose broth gave comparable results, with specificity of "EC" for coliform organisms slightly better. Increasing use of streptococci as indication of fecal poln. in swimming pools, because of their greater resistance to chlorination, led to the devising of medium selective for these organisms and known as "SF" (i.e., *Streptococcus faecalis*). Combines use of inhibiting agent sodium azide, and incubation temp. of 45.5°C. Both "EC" and "SF" media found highly selective for coliform bacteria and for fecal streptococci, respectively, in milk. Formula for each medium given.—*Martin E. Flentje.*

The Effect of Concentration of Dyes on Differentiation of Enteric Bacteria on Eosin-Methylene-Blue Agar. MAX LEVINE. J. Bact. **45:** 471 (May '43). American certified methylene-blue contains approx. 50% more dye than old Grübler product. In prepg. E.M.B., adjusting for this higher dye content essential to avoid growth inhibition and development of atypical paratyphoid-dysentery colonies. For best results, ratio of eosin to methylene blue (actual dye content) should be approx. 6 : 1 to provide sufficient excess of eosin, insuring absence of any appreciable quant. of uncombined methylene blue. Medium reaction should not be more alk. than pH 7.4. Following E.M.B. compn. suitable for coliform differentiation and detection of paratyphoid-dysentery group members. *Basal Medium:* agar, 15 g.; peptone (Difco), 10 g.; K_2HPO_4, 2 g.; and water (distd.), 1000 ml. Sterilize 15 to 20 min. at 15 lb. *Differential Medium:* To 100 ml. of melted basal medium add: lactose (20% sterile soln.), 5.0 ml.; eosin yellowish (2% aq. soln.), 2.0 ml.; and methylene blue (0.5% aq. soln.), 1.3 ml., or (0.325% aq. soln.), 2.0 ml. All constituents may be added before sterilization.—*Ralph E. Noble.*

Mechanism of Selective Action of Eosin-Methylene-Blue Agar on Enteric Group. E. S. WYNNE, L. J. RODE & A. E. HAYWARD. Stain Tech. **17:** 11 ('42). Eosin and methylene blue in medium react to form compd. of nature of acid or neutral dye. Lactose-fermenting colonies produce sufficiently low pH for individual cells to stain with this compd. Some colonies produce high pH which causes slight dissociation of compd., so that colonies may stain independently with methylene blue. —*C.A.*

Staining Bacterial Capsules. P. H. H. GRAY. J. Bact. **45:** 301 (Mar. '43). Following modification of Muir's method for demonstrating bact. cell capsules gives consistently good results, yielding more well-defined capsules than original, due to omitting ethyl alc. treatment after first staining operation. Prep. light suspensions in tap water and dry loopful on well-roasted cool slide; do not spread film

fix by gentle heat. Place small filter paper rectangle over film and oversaturate with carbol fuchsin. Heat by passing 14 times (7 sec.) through flame, or until steam rises. Paper keeps stain in place on film when slide cool, after 30 sec. on bench, wash off paper and excess stain. Apply Muir's mordant 5 to 15 sec., wash well in running water, re-stain 30 sec. with suitable staining soln. contg. methyl alc. Good results obtained with: (1) methyl hydrate, 50 ml.; 1% aq. soln. basic fuchsin, 50 ml.; (2) methyl hydrate, 50 ml.; 1% aq. soln. methylene blue, 50 ml.; and (3) mixture of Nos. 1 and 2 in ratio of 10 : 5. Contrast between red cell and blue capsule better with No. 3 than No. 2. Capsules well differentiated with soln. No. 3 in beef-peptone agar cultures of: *Aer. cloacae, Esch. coli, Eberthella typhosa, Ps. aeruginosa* and others listed. Films examd. by light from 100-w. lamp. Some capsules seen better if ground glass screen under condenser.—*Ralph E. Noble.*

The Viability of Dysentery Bacteria in Well Water. W. STEUER. Arch. Hyg. (Ger.) **126:** 228 ('41). Results published by different investigators on viability of *Shigella dysenteriae* in water give varied results. In Cracow dist. of Poland where dysentery common, much of water supply even in towns drawn from badly constructed and neglected wells. Author describes tests carried out on viability of dysentery bacteria in pold. water of type drawn from these wells. 3 types of *Shigella dysenteriae* tested at 37°C., at room temp., and at −3°C. Times of survival varied but always longer at lower temps. Thus, generally, low temp. of well water not unfavorable to their survival. Time of survival in water which might be regarded as good drinking water long enough to constitute a danger, even after one isolated occurrence of poln. In pold. water of wells examd. bacteria survived at room temp. for several days, and in some instances for over 1 wk. Coliform titer of waters examd. varied from 0.1 to 100 ml.; did not affect viability of dysentery bacteria. Author concludes that well waters constitute source of infection and that improvement of water supplies important factor in control of dysentery.—*W.P.R.*

Sulfonamide-Resistant Strains of *Shigella paradysenteriae* and *Shigella sonnei*. MERLIN L. COOPER & HELEN M. KELLER. (*Published in abstract only.*) J. Bact. **45:** 26 (Jan. '43). One strain of *Shigella paradysenteriae* and 2 of *S. sonnei* became resistant to Na sulfathiazole *in vitro*. Bactericidal concns. of Na sulfathiazole, Na sulfapyridine, sulfanilamide, Na sulfadiazine, sulfacetimide and sulfapyrazine detd. *in vitro* for the 3 resistant strains and their nonresistant parent strains. High concn. of each sulfonamide prepd. in Bacto nutrient-broth according to soly. After autoclaving, dilns. prepd. to obtain sulfonamide concns. between 1 and several hundred mg. per cent. Inoculum of 30–45 organisms per ml. added to each 10 ml. sulfonamide broth. Bactericidal concns. detd. after 2, 4, 7, 14 and 21 days incubation by subculturing tubes without visible growth. Lowest concn. bactericidal after longest incubation period considered final bactericidal concn. Most striking result was that 3 strains originally resistant to Na sulfathiazole each non-resistant to sulfapyrazine, while 2 Sonne strains resistant to Na sulfathiazole not resistant to sulfacetimide. Flexner strain very resistant to latter, 1000 mg. per cent being non-bactericidal. Na sulfadiazine not bactericidal in 1000 mg. per cent concn. for 2 parent and sulfathiazole-resistant Sonne strains and sulfathiazole resistant Flexner strain. This drug bactericidal, however, for parent Flexner strain in 50 mg. per cent concn.—*Ralph E. Noble.*

Resistance and Dissociation of *Shigella sonnei*. OSCAR FELSENFELD. (*Published in abstract only.*) J. Bact. **45:** 25 (Jan. '43). Resistance of 10 *Shigella sonnei* strains compared with resistance offered by 15 other manitol-fermenting strains of *Shigella*. While members of *Shigella paradysenteriae, alkalescens* and *dispar* groups reacted quite uniformly to heat, drying and sulfa drugs and survived also for approx. same period in water and milk, various *Shigella sonnei* strains showed marked disparity. Greatest differences noted in min. bacteriostatic doses, min. sulfa-drug concn. necessary to check colony dissociation and amt. of anti-inhibitory agents to counteract sulfa-drug influence. Observed that colony forms associated with greater fermentative activity more resistant to sulfa drugs and phys. agents. Findings, therefore, may explain irregular effects of sulfa drugs in various dysentery epidemics. Higher percentage of post-epidemic *Shigella sonnei* carriers possibly due to survival of more resistant dissociation forms. No qual. differences in action of sulfathiazole, sulfaguanidine and sulfasuccidine on *Shigella sonnei* and other *Shigella* members studied.—*Ralph E. Noble.*

Biochemical and Antigenic Relationships of the Paracolon Bacteria. C. A. STUART, K. M. WHEELER, ROBERT RUSTIGIAN & ALICE ZIMMERMAN. J. Bact. **45:** 101 (Feb. '43). Paracolon organisms, aberrant coliform organisms in man isolated especially during gastro-enteritis outbreaks, comprise distinct biol. group. Specialization proceeds independently in *Aerobacter*, intermediate and *Escherichia* sections and high deg. of physiol. specialization reached even by *Aer.* types, e.g., type 37511, although resembling *Aer.*, fails to ferment lactose, sucrose, salicin or cellobiose; gives weak or neg. V.P. reaction upon isolation; occasionally fails to grow on citrate agar; and does not liquefy gelatin. Other members of 3 sections differ from normal coliform organisms and, considering physiol. properties, paracolon forms intermediate between normal coliform organisms and *Salmonella*. Marked difference found in antigenic continuity of normal and paracolon groups. Normal *Aer.* tested in normal *Aer.* antiserums, normal intermediates in their antiserums and normal *Esch.* in own antiserums showed 0.0, 8.2 and 33% respectively identical or closely related. Similar tests with *Aer.*, intermediate and *Esch.* paracolon cultures in respective antiserums showed 47.8, 52.5 and 67.2%. Known somatic *Salmonella* antigens occasionally found in normal coliform organisms and paracolon. Unidentified somatic antigens common to normal coliform organisms, all sections; to paracolon, all sections; and *Salmonella* frequently encountered. Also, Vi-like somatic antigen common to *Eberthella typhosa* S-107, *Salmonella ballerup* and several normal coliform and paracolon types found. Some evidence of geographical segregation in paracolon group as, with few exceptions, strains from one locality frequently identical with other cultures from same, but seldom with those from different localities. Although 72.9% of more specialized paracolon cultures identical with or closely related to one or another of cultures for paracolon antiserums, 96 cultures remained unidentified by 26 antiserums. Because of their complex serological structure, paracolon classification impracticable on basis of H and O antigens. With serological and physiol. properties, apparently no sharp distinction exists between groups while more or less continuous series of types do exist. Paracolon pathogenicity not proved. Often found associated with mild or acute gastro-enteritis of short duration. Some evidence indicates etiological rôle for types 1811, 31611, 32011 and especially 33111.—*Ralph E. Noble.*

A Study of Two Atypical Strains of *Eberthella typhosa*. DOROTHY N. SAGE & E. H. SPAULDING. J. Bact. **44:** 647 (Dec. '42). Two biochem. atypical strains of *Eberthella typhosa* from clinical typhoid fever observed 3 yr. Upon isolation, lactose and sucrose fermented but H_2S not produced. Became entirely typical only after 1 yr. of artificial cultivation. All attempts to reinduce lactose fermentation failed. Serologically, both strains possessed considerable "Vi" antigen but only small amt. of flagellar antigen when isolated. No other unusual antigenic property observed. Periodic feces isolations from carrier revealed gradual transition from abnormal biochem. pattern first observed to completely typical one 3 yr. later. Because H_2S not produced initially, neither strain detected in bismuth sulfite agar. Not unlikely that similar variants occasionally occur among H_2S-pos. *Salmonella* group. Sole reliance, therefore, upon this type of medium for primary isolation of H_2S-pos. enteric bacilli undesirable. Two cases described illustrate that markedly atypical strains may cause classical form typhoid fever. Both patients presented usual symptoms at onset and subsequently pursued customary typhoid course.—*Ralph E. Noble.*

Notes on the Relation Between Coliform Organisms and Enteric Pathogens. ROBERT W. KEHR & CHESTER T. BUTTERFIELD. Pub. Health Rpts. **58:** 589 (Apr. 9, '43). To maint. clear perspective revalue of coliform test as indicator of poln. and, therefore, of possible infection with enteric pathogens, evidence presented tending to clarify coliform-pathogen relationship. Particularly worthwhile as coliform test recently received adverse decision by Illinois Supreme Ct. as to its value for indicating unsafe water. Available quant. data on relative prevalence of coliform organisms and *Eberthella typhosa* in sewage and sewage-pold. waters summarized and presented as ratio of *Eberthella typhosa* per million coliform organisms at varying levels of typhoid fever morbidity in community contributing such poln. Evidence presented that such ratio could be expected to remain const. through bact. reductions by natural purif. processes approxg. 99.9%. Data also summarized re coliform and *Eberthella typhosa* decrease rates in 3 temp. ranges. Theory presented that min. infectious dose of *Eberthella typhosa* in man is single bacterium. Based on this theory and relative concn. of *Eberthella typhosa* and coliform organisms present in sewage from large pops., estd. that possibly

1 or 2% of persons who ingest single *Eberthella typhosa*, develop typhoid fever. Anal. of available data in literature presented. Emphasizes basic value of coliform test as indicator of possible presence of pathogens, indicating very real danger may exist when coliform organisms present in even moderately high concns; e.g., authors applied their developed principles to data on typhoid outbreak at Detroit, Feb. '26, and calcd. that 9 cases of typhoid fever would have developed, expectancy only slightly greater and of same order of magnitude as actually developed, namely, 8 cases of typhoid fever and 45,000 cases of gastro-enteritis. Safety factor provided by ratio of million or so coliform organisms present for each *Eberthella typhosa* would, presumably, allow for unusual fluctuations in ratio of *Eberthella typhosa* to coliform organisms provided coliform density in ingested media kept quite low or elimd. by methods reducing gen. bact. pop. [Assumption of "typhosa-coliform" ratios logical and rational approach to more active and quant. use of coliform est. as indicator of san. conditions. This ratio supported by considerable presented evidence and should give, if not absolute, legal status to coliform test recently ruled against in Ill.]—*Ralph E. Noble.*

Biochemical Characteristics of Pigmented Coliform Bacteria. J. RICHARD GILILLAND & REESE H. VAUGHN. J. Bact. **45**: 499 (May '43). Studied 15 chromogenic coliform organisms. On basis of qual. and quant. data, 12 in genus *Escherichia*, 3 in genus *Aerobacter*. Several factors influencing pigmentation investigated. Incubation at relatively low temps. necessary for pigment production by 12 cultures, *viz.*, 19°C. but not at 30° or 37°C. Three, however, able to produce pigment at 37°C. Pigmentation observed with organisms grown on mineral salts, glycerol, agar medium. Anaerobic glucose metabolism of typical strains studied and compared with fermentations by *Esch.* and *Aer.* members as reported in literature. No signif. deviations from typical dissimilations observed as shown by C-H balances.—*Ralph E. Noble.*

The Growth of Coliform Bacilli in Water Containing Various Organic Materials. J. H. NELSON. J. Path. & Bact. **54:** 4: 449 (Oct. '42). Presents results of testing effect of various org. materials on growth of coliform bacilli in distd. water and in raw and autoclaved tap water. Same coliform bacillus, an "intermediate," used throughout. Substance to be tested sterilized in autoclave before introduction into exptl. flasks. Autoclaved tap water itself growth-supporting to coliform organism at 37°C., but this power enhanced by addn. of string. Unheated tap water with string gave no growth. 28 other org. substances tested in same way. Substances included oak acorn, bone, cotton-wool, cork, filter paper, hair, hay, leather, various types of leaf, linen, linseed, meal, paper, pine cone, potato, rubber, sacking, sawdust, straw and wood. Paper, rubber and non-absorbent cotton-wool inhibitory in that no growth occurred in either raw or autoclaved water. Possible that some inhibitory substance used in their prepn. All remaining substances supported growth in autoclaved tap water to greater or less deg.; all substances, except leather, supported growth in autoclaved distd. water; all, including leather, but excluding linen and absorbent cotton-wool, supported growth in untreated tap water. Expts. carried out at 22°C. except for slower rise to peak of growth. Findings important in connection with bact. examn. of drinking water. Vegetable matter such as leaves, wood, etc., if introduced into well water contg. small no. of coliform organisms might, under conditions of increased temp., cause these to increase to a sufficient extent to condemn water by stds.—*B.H.*

The Incidence and Significance of Microorganisms Antagonistic to *Escherichia* in Water. DORIS HUTCHISON, R. H. WEAVER & M. SCHERAGO. J. Bact. **45:** 29 (Jan. '43). By Waksman and Woodruff's method, microorganisms antagonistic to *Esch. coli* isolated from following samples of waters: well, 5 of 44; spring, 1 of 12; surface, 6 of 16; cistern, 0 of 7. Antagonists included 3 strains *Pseudomonas*, 2 *Actinomyctes*, 1 each *Sarcina*, *Micrococcus*, *Flavobacterium* and yeast and 3 unidentified non-spore-forming, Gram-neg. rods. When water samples inoculated with 10,000 to 20,000 antagonists and approx. 10 *Esch. coli* per ml. stored at 10°C. 12 hr., 8 of 12 antagonists reduced *Esch. coli* nos. When similar samples stored at room temp. 24 hr., 11 of 12 antagonists likewise reduced *Esch. coli* nos., 3 destroying all *Esch. coli*. M.P.N. values of *Esch. coli* suspension reduced 28–97% when various antagonists inoculated into lactose broth tubes simultaneously with serial diln. planting of suspension. *Esch. coli* recovered on Endo or E.M.B. agar plates from all tubes showing gas, but nos. of colonies apparently reduced by presence of antagonists. —*Ralph E. Noble.*

HYDRAULICS

Flow Characteristics of Pipelines, With Special Reference to the New Pressure Aqueduct of the Metropolitan Water District. WILLIAM F. COVIL. J. Boston Soc. Civ. Engrs. **29:** *Sec. 1:* 22 (Jan. '42). Pipeline flows may be computed conveniently by reducing all head losses to basis of loss in ft. for unit quant., such as 1 mgd. This may be termed "flow characteristic." Darcy formula may be reduced to $h = CfQ^2$ and, by considering relation of f to Reynold's no., taking kinematic viscosity as const. $h = CQ^n$. For any unit quant., Q, $h_{Q1} = (h/Q^n)$ = flow characteristic = K_f. Flow characteristic may be conveniently used in expressions for divided flow in systems of pipe by $K_{fB} = K_{f1}Q_1^n$, or $K_{fB} = K_{f2}Q_2^n$. For computing Metropolitan Aqueduct flow $K_f = h/Q^2$ used, giving greater simplicity than if odd exponent for Q, such as 1.85, used, as in Williams-Hazen formula. By preparing table for Reynold's no., value of f may be obtained. Computing h and plotting on log. paper gives $h = CQ^{1.93}$, considered close enough to Q^2 for all practical purposes. Aqueduct in question consisted of several types and sizes, from horseshoe twin section 7′3″ high by 4′7″ wide, up to 14′ tunnel. Flow of 400 cfs. assumed higher than normal so as to indicate all losses, however small. Losses computed in ft. to 3 and even 4 decimal places. Using $n = 0.012$ for pipe and $n = 0.013$ for tunnels in Manning's and Kutter's formula, total loss estd. at 19.2′ compared with 18.7′ calcd. from tests. Minor losses total 13%. Worksheets mimeographed for computing losses by Manning, Kutter and Scobey formulas, use of three resulting in easy check. Rough pencil sketches permitted numbering points of loss, which, together with flow diagrams, clarified computations. K_f for entire line was 0.0002860. Time spent in such study well spent, minor losses reaching appreciable total. Fundamental criterion to deliver most water for least money consistent with life requirements. Minor losses increase in importance as diam. increases. These based on veloc. head. Tests showed reasonableness of $n = 0.012$, giving K_f of 0.0002777. For 11′6″ pipe, $n = 0.0116$ and $C = 146$. *Conclusions:* Method described useful for networks and for use in Hardy Cross method. All formulas omitted once flow characteristic detd. Use of 2 as exponent for Q simplifies computations and permits ready use of slide rule. Writer credits Karl R. Kennison with origination of method.—*Charles H. Capen.*

Loss in Head in Flow of Fluids Through Various Types of 1½-Inch Valves. WALLACE M. LANSFORD. Univ. of Ill. Eng. Expt. Sta. Bul. 340 (Feb. 2, '43). Purpose to det. loss of head (l.h.) accompanying water flow through small valves. All latter used in study 1½″ nominal diam. Most available information on l.h. in valves more than 20 yr. old. Little information, therefore, re valves of recent mfr. Effort made also to study test results by means of dimensionless parameters, as customary in studying flow of fluids through pipes, to make results more useful to engrs. concerned with fluids not water. Dimensionless parameters used were K_v, ratio of head loss in valve to avg. veloc. head in pipes, and **R**, Reynolds no. for flow conditions in pipe. Gate, globe, check and Y valves tested. L.h. in all varied closely as sq. of avg. veloc. in pipe. Veloc. ranged from min. of less than 1 fps. to max. of more than 50 fps., depending on type of valves used. L.h. due to 1½″ gate valve when wide open nearly same as that per ft. in 1½″ galv. pipe. L.h. due to gate valve ½ open, approx. 25 times l.h. when wide open, veloc. in pipe being same for the 2 settings. L.h. for wide open globe valve about 40 times l.h. in wide-open gate valve; pipe veloc. same in both cases. Check valve l.h. varied greatly depending upon type of checking mechanism. Swing check valve developed only $\frac{1}{10}$ as much l.h. as horizontal disc check valve and only $\frac{1}{4}$ as much as ball check valve. Latter, however, might be advantageous despite high l.h. because ball vibrations tend to keep valve seat clear. L.h. in wide open Y valve about 20 times that in wide open gate valve, but only $\frac{1}{2}$ that in wide open globe valve. Direction of flow through globe or Y valves caused little difference in l.h. For all valves tested, valves of K_v approached const. value as **R** increased. By using exptl. values obtained, value of K_v obtainable for any of valves tested, regardless of fluid type flowing, if **R** computed, i.e., if viscosity, density, veloc. of fluid and pipe diam. known. Thus, l.h. computable from K_v in curves shown, for wide range of liquids and gases of various temps. and densities. One curve, therefore, will yield information for

great variety of conditions of different fluids within limits of **R** values used in these tests. For globe valves tested, K_v remained const. over entire range of **R**, varying from less than 20,000 to more than 50,000. Avg. K_v value for wide open globe valves ranged from 5.5 for bevel-seat type to 8.2 for plug-disc type.—*Ralph E. Noble.*

The Use of Current Meters in Measuring Pipe Discharges. CARL ROHWER. Colo. Agric. Expt. Sta., Tech. Bul. No. 29 (Sept. '42). Free outlet pipe discharges commonly measured with weir, Parshall flume, meters, orifices and flow gages, requiring special installation, expensive and time-consuming. To obviate difficulties, investigated feasibility of measuring discharge with current meter in outlets of 4″, 5″, 6″, 8″ and 12″ std. pipe and 7″, 8″ and 9″ od. pipe when flowing at different rates. Simultaneously same discharge measured over std. weir or other suitable device previously calibrated volumetrically. Quants. measured ranged from 50 gpm. for 4″ pipe to 3700 gpm. for 12″ pipe. During first season all tests made on pipes 8′ or 10′ long. Because length might affect accuracy, second season tests made on 2½′, 6′ and 14′ lengths. Latter tests made only on 6″, 8″, 10″ and 12″ pipes. Methods of conducting expts. described. In measuring pipe discharge with current meter, found that product of area and veloc. not equal to discharge. Too large, probably, because current meter did not measure low velocs. near pipe walls. Correction factor required and found const. under std. conditions for each size regardless of discharge so long as veloc. insufficient to affect current meter registration. Veloc. became too great for accurate measurement at approx. 10 fps. in 12″ pipe and 9 fps. in small pipe. Gen. law showing relation between veloc. as measured by meter and discharge for all pipe sizes given by formula $Q = (419A - 5)V$ in terms of pipe area, and $Q = 1.815^{2.09}\ V$ in terms of pipe diam. Both formulas give satisfactory results, but discharges computed by first formula, in gen., slightly closer to actual ones. Comparison of observed and computed discharges for all tests regardless of conditions except those with spiral flow showed 79% of computed results not more than 3% in error and 92% not more than 5% in error. Holding meter in pipe obstructs flow to decrease discharge and build up head. Although effect relatively small, correction necessary when accurate test of pump desired. Readily made after measuring head increase by ref. to head-capac. curve of pump. Two methods of integrating flow with current meter investigated and both found equally satisfactory. Combination of horizontal, vertical and circular integration recommended because discharge formulas based on measurements by this method. Statistical anal. of effect of pipe length on current meter accuracy showed differences insignif. *Outlet pipes at least 6′ long recommended because obstruction in pipe or other disturbing factor has less influence in long pipes.* Both Ott meters and Hoff rubber-propeller meters of type tested equally satisfactory in measuring pipe discharges. Measurements of same quant. by different observers with different meters agreed quite closely to true discharge. Adding elbow at pipe inlet to simulate condition found in pump discharge pipes did not affect accuracy of current meter registration for lengths greater than 6 diams. Right-angle inlet in horizontal plane materially affected registration if outlet pipe 2½′ long but had little effect if 6′. Spiral flow measurements with current meter found unsatisfactory. Spiral flow to left had greater effect than to right. Straightener vanes in pipe effective in straightening lines of flow and reducing measurement error to less than 3%. Slight slope in discharge pipe or roughness due to pitting or rusting did not affect measuring accuracy. With air inlet at upper end, difficult to make pipe run full unless outlet submerged, but if full, meter registration unaffected. Submerged pipe outlet did not change registration. Several hundred field measurements of pumping plant discharges disclosed difficulties in making measurements sometimes encountered because discharge pipe not flowing full, veloc. too low to measure with current meter, or pipe area not readily detd. because outlet submerged or badly distorted. In gen., however, method satisfactory and great time saver. Under favorable conditions, possible to make complete measurement and compute results in 15 min.—*Ralph E. Noble.*

Flow Around Bends in Stable Channels. C. A. MOCKMORE. Proc. A.S.C.E. **69:** 335 (Mar. '43). 2 causes of spiral flow in either closed or open channels are: (1) existence of friction on channel walls, resulting in higher filamental velocs. near center of channel than

near walls and (2) centrifugal force required to deflect particles of water from straight-line motion. Since vertical curve of veloc. variation in stream cross-section approxs. parabola, natural that cross-currents of spiral be most pronounced near bottom of stream. If channel under consideration happens to be rather wide and comparatively shallow, if water flowing through bend (such as may exist in natural river) and if it encounters channel irregularities, undoubtedly will be localized turbulence which may tend to distort spiral flow pattern. Suppose open-channel of rectangular section be considered and that assumptions be made with regard to components u, v and w of veloc. parallel, respectively, to x-axis, y-axis, and z-axis for frictionless fluid, then there will be: (1) Parabolic variation of u-component starting with zero at each side wall and becoming max. on y-axis midway between side walls; straight-line variation of u-component, starting with zero at mid-depth of channel and becoming max. at top and bottom of channel, with opposite signs. (2) Straight-line variation of v-component, starting with zero on y-axis and becoming max. at each side wall, with opposite signs; parabolic variation of v-component, starting with zero at top and bottom of channel, with max. value at mid-depth. (3) Parabolic variation of w-component, starting with zero at bottom and becoming max. at water surface; parabolic variation of w-component, starting with zero at each side-wall and becoming max. on y-axis midway between side walls. Equation of streamlines (when defined as curves) given, together with equation of acceleration in free vortex flow. Path taken by particle on its way around bend in open channel extremely complicated and varied, but, in general, must follow spiral. Concluded that: (1) spiral flow in bends of open channels, as enunciated by James Thompson, exists, although spiral pattern exceedingly complex; (2) downstream components of filamental velocs. in first half of bend greater near convex bank than at concave bank and vary across channel in close agreement with law of free vortex; (3) angular velocs. and accelerations inherent in spiral motion constitute strong contributing factors to movement of bed load not only in downstream direction but toward inside of bends; (4) at about ¾ way around bend, tendency for development of eddy or slack water along inside bank, due to spiral motion, which is conducive to deposition of suspended matter and formation of bar.—*H. E. Babbitt.*

Entrainment of Air in Flowing Water. *A Symposium.* Proc. A.S.C.E. **68:** 1099 (Sept. '42) (*Abstracted,* Jour. A.W.W.A. **35:** 365 ('43)). *Discussion. Ibid.* **69:** 166 (Jan. '43). WARREN DELAPP: Although amt. of air entrained in water should depend primarily on Froude no. (**F**), also should depend, to some extent, on channel roughness, since latter will affect intensity of agitation of flow for given value of **F**. Actual form of function appears to be $Q_{aw}/Q_w = K\mathbf{F}$, in which Q_w = water discharge; Q_{aw} = combined quant. of air and water; **F** = Froude no. = $V/\sqrt{gy_o}$; V = avg. veloc. in section; y_o = depth of flow; g = acceleration due to gravity; and K = dimensionless no. whose value depends on roughness of channel. Form of eq. indicates simple relationship between y_o and q_w, water discharge per unit width of channel, so that $y_o = K^{\frac{2}{3}}\sqrt[3]{(q_w^2/g)}$. Remains to evaluate K in terms of channel roughness, information available being scarcely sufficient for that purpose. In spite of this, however, latter eq. should prove adequate for design of straight chutes at uniform grades, relatively small variation of coef. making selection of no greater uncertainty than that normally encountered in choice of n, Kutter's or Manning's roughness coef. *Ibid.* **69:** 306 (Feb. '43). KARL R. KENNISON: Expts. reported throw considerable light on behavior of water in elimg. air pockets from high points in pipelines. In considering capability of water to remove air, **F** particularly important for showing when flow subject to surface waves of considerable height. Well known that such waves can occur very easily in any kind of channel, where **F** = 1. Messrs. Kalinske and Robertson obtained considerable information as to capability of hydr. jump to pump air through itself into next bubble. Fact that air cannot escape makes it necessary to include in formula for hydr. jump in closed pipe factor representing amt. of air pumped and extent to which it decreases sp.gr. of water. From study of test results, in spite of theoretical considerations, there seems to be limiting min. depth beyond which jump cannot fill pipe, because approaching jet of water confined laterally by shape of pipe invert. To fill pipe requires much higher rate of discharge than momentum eq. of jump would indicate. Ultimate aim of designer in dealing with these matters not just to remove air, but to remove it so as to make most effective saving of head or to prevent air binding. *Ibid.* **69:** 435 (Mar. '43). ROBERT T. KNAPP: Until quite recently, little attention given to

curvilinear flow in high-veloc. open channels. When applied to flow of liquid in open channel, term "high-veloc. flow" means flow at veloc. greater than critical or wave veloc. for that particular depth. Air entrainment through free surface of flowing liquid essentially wave phenomenon. More exactly it is accomplished through medium of breaking waves which fold in air and carry it through interface. Thus, it is surface phenomenon and, because of nature, is restricted in gen. to velocs. of flow above critical. Some conclusions are: (1) non-uniform vertical distr. of air to be expected; (2) amt. of air entrained probably will be affected by magnitude and veloc. of wind at surface of flow; (3) initial disturbances necessary to cause wave formation; (4) channel roughness should be one of most important factors in air entrainment; (5) methods of veloc. measurements that basically det. veloc. of upper layers probably unreliable and underest. true veloc.; and (6) since entrainment and transportation of air and sediment have many points in common, appears that parallel treatments should yield many useful results. CARL E. KINDSVATER: Data obtained from jumps in sloping pipe verify application of pressure-momentum anal. to that phenomenon. Of interest to attempt explanation of small but definite tendency for observed "force plus momentum" after jump to be less than sum of initial pressure and momentum. 3 explanations offered by writer: (1) because of non-uniform distr. of velocs. in Sec. 2 computed momentum, based on assumption of uniform distr. of avg. veloc., less than true momentum in cross-section; (2) because of admixture of air with water in Sec. 2, true veloc. of water somewhat greater than avg. veloc. based on total cross-sectional area of conduit; and (3) because of extremely turbulent non-uniform flow conditions below jump, impossible to compute accurately loss of head due to wall friction between Secs. 1 and 2. Numerous studies on hydr. jump in open channels demonstrated that length can be conveniently expressed as function of **F**. *Ibid.* **69:** 515 (Apr. '43). J. H. DOUMA: Hydr. design of channel walls, horizontal curves, vertical curves, superelevated inverts and of stilling basins should be based on new design assumptions and formulas involving entrained air. For high-veloc. flow, large vols. of air set in motion with addnl. losses not included in Manning's formula. In Manning formula, veloc. varies as 2/3 root of hydr. radius. Increase in air content and corresponding larger hydr. radius would result in higher veloc. This result opposite that experienced with aerated flow. For aerated flow, expression $1.486/n$ in Manning formula can be changed to N/n, in which values of n same as established for non-aerated flow and N is function of air content. Modified formula becomes $V = (N/n)R^{\frac{2}{3}}S^{\frac{1}{2}}$, in which V = veloc. of flow, R = hydr. radius and S = slope. Avg. relationship of u and n given by $n = \frac{60}{6.000 - u^2}$, in which u = percentage entrained air, by vol. Avg. relationship of u and N given by $N = 1.486 - 0.000248\ u^2$. Eq. for vertical invert curve is $y = -\left(x \tan\theta + \frac{x^2}{4H_o \cos^2\theta}\right)$, in which y = ordinate, x = abscissa, θ = angle of channel bottom or pipe with horizontal and H_o = total vertical drop from original water surface at top of chute to origin of vertical invert curve. For rapid flow, max. superelevation along outside wall given by $e_S = \frac{1.2V^2b}{gr_c}$, in which V = avg. veloc. in sec.; b = width; r_c = radius of center-line of channel; g = acceleration of gravity. Commonly used formula for jump height in rectangular channel is:

$$d_2 = -\frac{d_1}{2} + \sqrt{\frac{d_1^2}{4} + \frac{2d_1V_1^2}{g}}$$

in which d_1 and V_1 = depth and veloc. upstream of jump; d_2 = depth after jump and g = acceleration of gravity. Formula for jump height with aerated flow becomes:

$$d_2^2 = \rho d_1^2 + \frac{2\rho d_1 V_1^2}{g}\left(1 - \rho\frac{d_1}{d_2}\right)$$

in which ρ is ratio of water in mixture of air and water. Formula can be solved for d_2 by trial and error. JOE W. JOHNSON: Air-water flow ratio, β, may not have same value as air-water ratio of mixture, hereafter termed Δ. When air and water not moving at same veloc., "slip" occurs, in which case β should be replaced by Δ. In Moore and Wilde expts. gas expanded as it flowed upward through pipe and "slipped" past water. Opposite condition probably occurred in Kalinske-Robertson expts.—i.e., water was "dragging" air along from low-pressure space to high-pressure space, and veloc. of water slightly exceeded veloc. of air. *Ibid.* **69:** 761, 847 (May, June '43). J. C. STEVENS: To design stilling basins at foot of high overflow dams one should know

veloc., depth and insufflation characteristics with which water reaches basin. Anal. of observed data that appears to give effective results presented. With insufflated flow, 2 conditions involved: (1) flow of liquid water measured at head, part of which remains liquid but unmeasurable, in field and in bottom of channel; and (2) mixt. of air and water riding on top of liquid water for which depths and velocs. may be observed. In any prismatic channel distance between assumed depths may be computed directly. Credit for basis of method must go to Alva G. Husted:

$$\Delta L = \frac{e_1 - e_2}{\cos\theta \tan\phi - \sin\theta} = (-\Delta e) \div \left[S_o - \frac{\cos\theta}{\cos\phi} S\right].$$

Study indicates that retarding effect of insufflation logically can be acctd. for by increasing roughness factor. D. N. McConaughy: Bur. of Reclamation interested in this field in recent years in connection with spillways for high concrete dams and for earth dams, in which chutes designed for large vols. of water at high velocs., form important part. Expts. for perfecting satisfactory app. and techniques for making necessary veloc. and depth measurements started in hydr. lab. about '37. Memo. from which exptl. data taken contained math. anal. by V. L. Streeter to which Hall's remarkably similar. Writer confesses to some bewilderment at multiplicity of formulas and of values of n and as to just how formulas are to be used. Experience of Bur. does not indicate that such confidence could be placed in Hall's veloc. measurements. Obtaining veloc., unfortunately, only part of problem, as depth, in some cases, of equal or greater importance. Depth measurements by means of staff gages on sides of channel gives depth more or less to top of spray as gage cannot be seen much below this surface. "Depth" should be defined. T. J. Corwin: In designing conduits with horizontal curves and relatively high velocs., ample freeboard should be provided because actual rise in water surface on outside of curves observed at about twice theoretical value. Most difficult problem in connection with chutes to develop suitable transition so water can enter without entrainment of air or surface waves.—*H. E. Babbitt.*

The Hydraulic Jump in Sloping Channels. Carl E. Kindsvater. Proc. A.S.C.E. **68:** 1473 (Nov. '42). (*Abstracted*, Jour. A.W.W.A. **35:** 369 ('43).) *Discussion. Ibid.* **69:** 31 (Feb. '43). Joe W. Johnson: From expts. in hydr. lab. at Univ. of Calif., B. D. Rindlaub developed relationship for calcg. principal dimensions of jump in sloping channels. Rindlaub assumed following equation to describe sloping channel jump:

$$\frac{Q\gamma}{g}(V_1 \cos\alpha - V_2) = \frac{b\gamma}{2}(d_1^2 - d_2^2) + W \sin\alpha \cos\alpha$$

in which W = weight of water in jump. Karl R. Kennison: Computations involved in theoretical deductions of formulas seem more complicated than warranted, but uncertainties in flows of this type. Problems generally deal with condition where neglected friction loss important item. In any formula for jump in sloping channels, this fact certain to vitiate results, particularly in case of low Froude numbers. Formula for hydr. jump in sloping channel can be simplified by equating momenta before and after jump, considering forces parallel to channel bottom, and by expressing height of jump as function of length. Momentum equation becomes:

$$d_2 = \frac{d_1}{2}\left(\sqrt{\frac{8\lambda}{\cos\alpha - x \sin\alpha} + 1} - 1\right.$$

in which d_1 and d_2 are depth of flow, in ft., at Secs. 1 and 2, resp.; λ is kinetic flow factor V_1/gd_1; tan α is slope of channel; $1/x$ is ratio of height to length of jump; V_1 is avg. veloc. of flow, in fps. at Sec. 1. Sufficiently accurate for practical purposes to assume that length of jump 3 times its height, or $x = 3$. *Ibid.* **69:** 719, 924 (May, June '43). J. C. Stevens: Beginning of jump definite and well defined, but end open to conjecture. On horizontal bed, end of jump taken, properly, as section where water surface reaches max. height. This end not end of roller, as author has considered it. General formulas for hydr. jump in rectangular channels—for negative slope, downward in direction of flow:

$$\frac{Q}{g} V_1 + \frac{d_1^2}{2} \cos\alpha + W \sin\alpha = \frac{Q}{g} V_2 + \frac{d_2^2}{2} \cos\alpha$$

and for positive slope:

$$\frac{Q}{g} V_1 + \frac{d_1^2}{2g} \cos\alpha = \frac{Q}{g} V_2 + \frac{d_2^2}{2g} \cos\alpha + W \sin\alpha$$

Writer has adopted length of jump given by Andrei Ivanchenko as:

$$L = 10.6\lambda^{-0.185}(d_2 - d_1)$$

Weight of body of jump for unit width is:

$$W = 10.6\lambda^{-0.185}\tfrac{1}{2}(d_2^2 - d_1^2)$$

Kineticity of jump is:

$$W = \frac{9.3}{k^{0.185}}\,\frac{d_2^2 - d_1^2}{2}$$

What have been called hydr. jumps on inclined beds of 1 : 6 or steeper, projecting into tailwater, not hydr. jumps at all, but mere plunging of water into pool. Live jet plunges into tailwater and, within steep section, follows slope downward with comparatively slow expansion and, obviously, relatively small losses. Two kinds of energy losses in hydr. jumps on inclined beds: (1) specific energy losses, i.e., losses with reference to stream bed; (2) geodetic energy losses, referenced to a horizontal datum. Specific energy loss is:

$$i_s = \frac{(J\cos\alpha - 1)^3}{4J\cos\alpha} \pm \frac{(J^2\cos^2\alpha - 1)(J\cos\alpha + 1)}{4J\cos\alpha}\tan\alpha$$

Geodetic energy loss is:

$$i_g = \frac{(J\cos\alpha - 1)^3}{4J\cos\alpha}(1 \pm m\tan\alpha)$$

Length of jump is:

$$m\left(J - \frac{1}{\cos\alpha}\right) = 9.3k^{-0.185}\left(J - \frac{1}{\cos\alpha}\right).$$

C. J. POSEY: Seems likely for steeper slopes, phenomenon may change entirely, jet plunging under with little localized impact and continuing far downstream as thread of high-veloc. current. Slope of 1 : 4 about steepest that can be used and still obtain satisfactory jump formation. With regard to author's use of λ, kinetic flow factor, might be well to note that factor of similar importance but of greater usefulness in practical hydr. work is ratio of veloc. head to depth. Representing this ratio by ω, equation of hydr. jump horizontal channel of rectangular cross-section becomes: $\frac{d_2}{d_1} = 2\sqrt{\omega + \frac{1}{16}} - \frac{1}{2}$. JEROME FEE: In energy phase of flow in steeply sloping channels, energy line has "fine structure" analogous to certain spectroscopic lines believed originally to be single lines. Later each found to consist of several lines, very close together, which could be sepd. under certain conditions. Avg. energy level of all particles in vertical section at point of intersection of "mean energy line" with section itself.—*H. E. Babbitt.*

Effect of Turbulence on Sedimentation. WILLIAM E. DOBBINS. Proc. A.S.C.E. **69:** 235 (Feb. '43). When 2 particles of nonflocculent material come together, only effect momentary mutual interference; if 2 particles of flocculent material come together may lose individual identities and become one. Thus, in suspension of nonflocculent material, sediment characteristics const., whereas, in suspension of flocculent material, continuously changing. In horizontal flow tank, any upward flow caused by secondary motion at some point must be compensated by downward flow at same rate at some other point. Complexities involved in anal. of secondary motions combined with those involved in anal. of coagulation phenomenon make anal. of sedimentation problem difficult. Study described concerns case of sedimentation of discrete particles of uniform size in stream in which turbulence fully developed. In turbulent stream, eddies dig into bed and carry material into suspension. Action opposed by settling of particles due to their own weight. If concn. at any elevation, y, be denoted by c, and settling veloc. of particles by w, rate at which material settles through unit area at el. y is wc. If state of equilibrium exists, rate will be balanced by rate of turbulent transport upward and $wc = \epsilon(\partial c/\partial y)$; ϵ being the kinematic turbulence coef. In distribution in which uniform intensity of turbulence is imposed on suspension of sand in water total sediment, W, held in suspension per unit area between any two elevations, y_1 and y_2 given by expression

$$W = \int_{y_1}^{y_2} c\,dy = \frac{c_1\epsilon}{w}\left(1 - \frac{c_2}{c_1}\right).$$

If values of concns. at any 2 els. y_1 and y_2 known, value of w/ϵ can be computed from

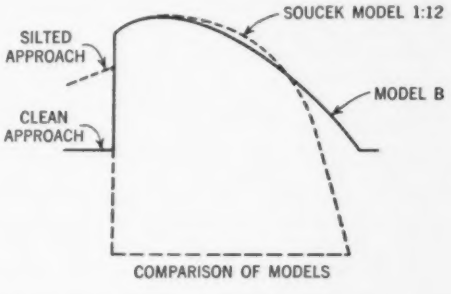
$$\frac{w}{\epsilon} = \frac{1}{y_2 - y_1}\log\frac{c_2}{c_1}.$$

Equilibrium condition approached but never fully reached. In settling tank, content of suspended matter at inlet much greater than

carrying capac., so material settles out. Discussion confined to two-dimensional case corresponding to conditions of steady, uniform flow in central region of wide channel. Solution for any practical case must satisfy not only differential equation for that case but also boundary conditions. Latter are 4 in number, 2 of which specify conditions that prevail at surface and at bed and 2 of which specify original and final distribution of suspended matter. Principal conclusions deduced from experimental results may be summarized as follows: (1) Further evidence of validity of log law for vertical distr. of sediment at equil. condition provided. (2) Equil. concns. independent of method by which material added to suspension. (3) Other things equal, equil. concns. depend on amt. of material available on bottom, up to point of satn. (4) When bottom satd. with given material, equil. concns. depend on hydr. conditions at bed. (5) Equil. concn. at any el. above bed independent of depth of fluid, provided that that at bottom satd. (6) Rate of pickup for unsteady conditions independent of total amt. in suspension; depends only on hydr. conditions at bed and characteristics of bed material, provided bottom satd. with material. (7) One-dimensional case of theory of turbulent sedimentation for discrete particles is verified. *Discussion. Ibid.* **69:** 779, 977 (May, June '43). JOHN S. MCNOWN: For sediment transportation in open channels, accurate evaln. of boundary condition provides principal stumbling block to solution of this troublesome problem. Direct measurements of settling velocity of particles would give check on degree of accuracy of results. Use of arithmetic mean value of settling velocities of doubtful accuracy. Concn. of smaller particles after comparatively long time may well have been many times greater than concn. of larger particles. Interesting byproduct of expt. indirect detn. of turbulence parameters. H. A. EINSTEIN: Author used, exclusively, "artificial turbulence," i.e., turbulence created by system of baffles rather than friction along sediment deposit. Intensity of resulting turbulence not measured and, therefore, no comparison with conditions in natural river is possible. THOMAS R. CAMP: Concn. of suspended matter at any depth in stream at equil. shown to depend primarily upon rate of scour from bottom. In settling tank rate of scour from bottom is always less than rate of settling out.—*H. E. Babbitt.*

Conformity Between Model and Prototype. *A Symposium.* Proc. A.S.C.E. **68:** 1267 (Oct. '42). (*Abstracted,* Jour. A.W.W.A. **35:** 36 ('43).) *Discussion. Ibid.* **68:** 1840 (Dec. '42). A. E. NIEDERHOFF: Since total similarity, geometric and dynamic, can never be obtained when same liquid used in both model and prototype, one should not be too disturbed at failure to obtain exact quant. results. Actual measurements of time, veloc. forces or discharges done best on full-size loca for possible design use on similar structure *Ibid.* **69:** 170 (Jan. '43). C. I. GRIMM: Acceptable formulas developed for use in desig crest profile of overflow concrete spillway Profile of crest of spillway reported by Stevens and Cochrane comes within limits of these formulas. Therefore, may be considered a conventional shape. Model study of spillway crests under controlled atm. pressure would be timely and of decided value as research project to supplement present knowledge JOE W. JOHNSON: Model studies made prior to constr. of prototype give valuable assistance in obtaining best design, but model studies made of existing structures more likely to be academic in character. Somewhat between limits was model study conducted at Univ. of Calif. on spillway crest of Upper Narrows Dam on Yuba R. Investigation intended to provide: (1) check on assumed discharge curve of spillway and (2) measurements of profile of nappe at various discharges, for purpose of predicting point where water would strike stream bed at base of dam. By using avg. curve drawn through exptl. points for 1 : 25 and 1 : 40 models, values of discharge computed for various assumed values of head. Plot of discharge *vs.* head on log paper gave relationship; $Q = 2.79\ H^{1.62}$. Mean curve through exptl. points of Soucek in his head-coef. relation obtained by model studies follows quite closely designer's curve based on Keokuk expts. Plot of curve yields equation $Q = 2.85\ H^{1.62}$. For almost all design problems this agreement can be considered well within limits of error to which certain basic design data can be estd. *Ibid.* **69:** 316 (Feb. '43). V. L. STREETER: Application of fundamental hydr. design principles rather than model studies will frequently give more reliable information at small fraction of cost. In many cases best method of predicting prototype performance is first to formulate analytical relationships for model performance. Discharge curve for outlet works one example

Using best values of f (friction factor), discharge for model may be obtained in equation form and various losses adjusted to agree with model exptl. data. When this accomplished, value of f should be changed to that anticipated in prototype. As minor losses are more dependent on Froude's no., they should not require alteration. Method permits evaln. of model performance in terms of prototype when Reynold's effects important. *Ibid.* **69:** 417 (Mar. '43). GLEN N. COX: Weir said to be submerged whenever tailwater rises to such el. that discharge over weir affected. Discharge over ogee submerged weir can be represented by formula: $Q = CL(H + [V^2/2g])^n$ in which Q = rate of discharge, in cfs.; L = length of crest, in ft.; H = measured head on dam referred to crest, in ft.; V = avg. upstream veloc. of flow; g = acceleration of gravity; C is a coef. and n an exponent. Both C and n depend on section of crest, type of flow, submergence and possibly other factors. *Ibid.* **69:** 528 (Apr. '43). GRAHAM WALTON: Variation of upstream head on weir due to change from plunging to flowing nappe noted. For same discharge over this particular trapezoidal weir, head for flowing nappe avgs. 2.5% greater than that for plunging nappe. Head measurement must be made at location not affected by nappe conditions or by downdrop curve resulting from downstream control section. For many submerged weirs used as measuring devices, head downstream must be detd. within that region affected by nappe conditions, particularly when flowing nappe discharge occurs. H. A. EINSTEIN: Friction given as cause for deviation between model and prototype. Usually this friction unimportant or may be corrected by calcn. Cases, however, in which true reproduction of this friction essential. In these cases method of distortion may be used which proves effective for river models. This raises question of reliability of distorted hydr. models in general. Exptl. data may prove that quantitatively similar river model with light-weight material in bed possible and that behavior can be predicted. Distortion, especially of time scale, unavoidable. Not possible to build quant. models for large streams with fine sediment. In this case, only qual. models producing qual. results can be built. K. G. TOWER: Models operated at atm. pressures will give thoroughly reliable soln. to problems susceptible to but questionable math. anals. Typical structures frequently constructed should be anald. in hydr. lab. in such manner that data obtained therein would constitute reliable guide to hydr. designer and elim. necessity for continual repetition of constr. and testing of models of structures nearly identical. R. J. PAFFORD JR: Numerous difficulties involved in obtaining accurate prototype data make this exasperating and expensive field. Utmost in ingenuity and fullest possible interchange in ideas essential. Developments along lines of sonic or electronic soundings also would seem to hold considerable promise for future, perhaps especially in cases complicated by spray and foam on top of "solid" jet. Writer had convincing demonstration of qual. accuracy of hydr. model in design of spillway stilling basin utilizing baffle piers for energy dissipation. EDWARD H. SCHULZ: Bldg. any structure where model studies and comparisons likely to be needed and where expense justified, provision should be made to incorporate appropriate accessories and equip. in prototype during constr. F. T. MAVIS: Writer conducted brief series of tests at Univ. of Iowa on model 11.25" high, designed as Model B in fig. (*below*). Model discussed by



Soucek shown for comparison. Relationship between submergence percentage, p, and ratio of submerged to free discharge for Model B: $C/C_o = 0.01[100 - 2^{0.2(p-70)}]$ in which C = coef. of submerged discharge and C_o = coef. for free discharge. Following conclusions seem justified: (1) differences in model spillway profiles shown in fig. not significant in reflecting behavior of prototype under conditions of free and submerged discharge and (2) generalized relationship between submergence percentage, p, and ratio of submerged to free discharge, C/C_o, as expressed by above equation, valid within scatter field observations on prototype. *Ibid.* **69:** 737, 967 (May, June '43). D. C. MCCONAUGHY: As result of

studies of model of "Little Dalles" on Columbia R. found possible to lower water surface upstream by 7′ at max. discharge contemplated (650,000 cfs.) by excavation estd. at 300,000 cu.yd. mostly in left bank. Unfortunately for purposes of discussion, no large discharges since work completed. Actual losses greater than those predicted from model except in one case, and difference seems to increase with increasing discharge. L. STANDISH HALL: Model of vertical shaft spillway of San Pablo Dam built on 1 : 14 scale. Found that if submergence of valves not greater than 6′, air bubbles, caused by impact of stream falling from top of shaft, could be carried through water cushion into horizontal leg of spillway. Tests indicate that strict conformity between model and prototype cannot be obtained under conditions of air entrainment in closed conduits. Operation of tunnel spillway under full discharge never satisfactory because of poor hydr. properties of tunnel inlet and outlet. Normal consideration of hydr. conditions at tunnel entrance would not reveal cause of pressure built up by entrained air at this point. Remedy directed toward cure of conditions of flow relatively simple, as in this instance only necessary to provide gates on entrance weir in order to preclude discharge of water over weir in excess of capac. of tunnel with free flow. Would be desirable, however, to study more fully all flow problems of this structure model test. A. J. GILARDI: In this discussion well to differentiate between generic conformity and specific conformity. Generic conformity refers to similarity of behavior, indications and tendencies between model and prototype; whereas specific conformity refers to agreement of measured quants. and derived coefs. in accordance with laws of hydr. similitude. First also might be called qual. conformity and second quant. conformity. In broad sense, generic conformity easier to ascertain mostly because reasonable similarity of constr. and conditions usually sufficient. Time when hydr. exptn. look upon as mere play and when securing funds for such work full of endless difficulties. Pendulum has swung too far in opposite direction. Definite tendency to place blind reliance on hydr. exptn. seems to have developed. FRANK W. BLAISDELL: In '39, at Hydr. Lab. of Natl. Bur. of Stds., writer tested several models of combination Parshall-flume and shallow Columbus-notch measuring devices. Found that in comparison of submergence curves for Parshall flume considerable scatter of data, but data obtained from either model can be used to define curve shown. In discharge computations for submerged flow conditions, models of rigid structures, without erodible boundaries and in absence of sediment transportation, can give highly accurate results although there are cases in which allowance required for scale effect. In cases of scour due to flow patterned mainly on shape of rigid structures, results obtained sufficiently accurate to have comparative and quant value. GILBERT H. DUNSTAN: Several yr ago std. 1′ Parshall flume constructed in Hydr Lab. at Univ. of Ala. Subsequently, small sheet-metal flume made with 2″ throat of prototype size. Prototype discharge obtained from model discharge by multiplying by $(L_r)^{2.5}$. Results obtained to date show good conformity. ROBERT F. KREISS. Writer regrets brief mention of dynamic head and overtravel and omission of any description of app for testing prototype locks. Writer agrees that inclusion of dynamic head effects satisfactory in model-prototype comparison. J. H. DOUMA: Qual. model studies, conducted under present-day technique, reliable in predicting many prototype conditions with satisfactory deg. of accuracy. Quant. comparisons, however, frequently show wide differences. Discrepancies often explained as due to lack of strict dynamic similarity. For model to be true representation of its prototype in every sense, both geometric and dynamic similarity must exist at same time. Basic dimensionless parameters pertaining to action of wt., viscosity, surface tension and elasticity known, respectively, as Froude, Reynolds, Weber and Cauchy numbers:

$$\mathbf{F} = \frac{\rho V^2}{\gamma L}\ ;\quad \mathbf{R} = \frac{VL}{\mu\rho}\ ;\quad W = \frac{\rho V^2 L}{\sigma}\ ;\quad C = \frac{\rho V}{E}$$

in which V = mean veloc., L = length, γ = sp.gr., ρ = density, μ = viscosity, σ = surface tension and E = elastic modulus. MARVIN J. WEBSTER: Design of app. for correlation tests between models and their prototypes often presents unusual difficulties. Especially true of app. used in prototype tests discussed by Nelson and Hartigan. Sketches of instruments used shown.—*H. E. Babbitt.*

Utilities Orders U-1 and U-1-f as Amended

IN recording the amendments to Order U–1 in the following pages, it is observed that the present terms of the order do not follow the pattern recommended by the representatives of water utilities present at a meeting in Washington, April 2, 1943. We shall not debate that now; but it is advisable to record at this time that water works executives are cutting the cloth for the suit they are going to have to wear. In other words, it is evident that water utilities generally are not using maintenance, repair and operating materials up to the extent that Order U–1 has for many months authorized. The time is past for academic squawking. Water works men cannot complain that a WPB order unduly restricts them in the field which the order covers and expect to obtain an amendment to it when the statistical evidence shows they are not using the quantity of material the order authorizes them to use.

Water works plants are being undermaintained. The tide of management policy must turn or the country is in for trouble with its water systems. Krug and Gorman warned water works men about this as plainly as possible at Cleveland. Discriminate between fundamental needs and frills. The frills can wait—the fundamentals must go on. Keep up maintenance, repair and operation to the degree required to insure, beyond doubt, the continued ability of the water system to meet the demands upon it. Your secretary has warned the field until he wonders how to say it again so that it will produce results. Here is one more try!

Mr. Water Works Superintendent:

You are responsible to your city for the maintenance and operation of its water service. The chances are about 10 to 1 that you are not using the amount of repair material that the War Production Board authorizes you to use. How can you justify the continued undermaintenance of your city's water system?

Instructions Re: Utilities Order U-1

Office of War Utilities

THE following discussion of changes in Utilities Order U–1 as amended September 24, 1943 was released on that date to "all electric, gas, water and central steam utilities." The amended paragraphs of the order, showing the changes made, are presented on p. 1375.

Short Items

The definition of "short item" in paragraph (a)(14) has been rewritten to limit the term to mean an item which a producer does not possess in sufficient quantity to meet his requirements for maintenance, repair and for operating supplies during the next 90-day period. For example, a producer estimates his next 90-day requirements of a certain size of pipe at 10 tons. He can obtain delivery of pipe in one month, at which time he estimates his stock will be reduced to 7 tons. Under U–1 he would be entitled to order 3 tons; that is, enough to bring his stock up to an estimated 90 days' supply of 10 tons at the time the new stock is delivered. This definition enables utilities to adjust their inventories of items of material to meet seasonal requirements. For example, an electric utility may require a larger stock of certain items of material to meet anticipated repairs that his experience shows will be required during the season of sleet or heavy icing conditions. He may build up his stock of these items to meet such requirements, and then, at the end of the winter season, lower his requirement estimate and permit his stock of these items to drop to a normal level of 90 days' supply at ordinary rate of use. Material, delivery of which is accepted under the short item provision, should be included in practical working minimum inventory and a corresponding dollar value of some other material should be transferred on the producer's records to excess.

Change in Assignment of Ratings

A substantial change has been made in paragraph (b) with respect to the assignment of ratings. The preference rating AA–1 is still assigned to the acquisition of material (except controlled material) for maintenance, repair and for operating supplies, *except for those to be used in building extensions of lines to consumer premises*. For acquiring material (except controlled material) for the latter purpose, however, the preference rating AA–3 is now assigned. This change is made to bring preference ratings for minor utility extension construction in line with preference ratings assigned for major utility construction. For example, the preference rating AA–1 may be used to purchase a transformer or a valve to replace a defective transformer or valve. If the transformer or valve is being purchased as a part of the installation of a new line to serve a consumer, however, the preference rating AA–3 must be used on the purchase order. Orders rated AA–1 and accepted by suppliers prior to the date of issuance of this amendment need not be down-rated to AA–3, even

though the material is to be used in building consumer extensions.

Controlled material is not affected by this change in preference ratings and controlled material for use in minor extensions is entitled to the same allotment number as material for any other MRO use.

It is realized that the assignment of the AA–3 rating for extensions made under U–1 and its supplementary orders will result in more record keeping for utilities but it is expected that this additional work can be kept to a minimum. It is not contemplated, for example, that utilities will maintain separate inventories of materials to be used in extensions. The regular U–1 inventories should be used for this purpose. To comply with the provisions of the order, utilities need merely keep a record of materials used from U–1 inventory for minor extensions built with "operating supplies," and when placing orders for replacement of material used from inventory, apply the AA–3 rating to the quantities used for such extensions. Of course, if any materials are purchased directly for use in extending lines to consumer premises, the AA–3 rating should be applied in the first instance, and not when it becomes necessary to replace these materials in inventory.

Paragraph (c)(3) has been amended to refer to Priorities Regulation 3 which lists certain items of material for the purchase of which preference ratings may not be used, or for which blanket preference ratings like that assigned by Utilities Order U–1 are not valid. Your suppliers of these materials will be able to inform you of the applicability of Priorities Regulation 3 to the items of that kind that they sell. Former Schedule E of U–1 containing an incomplete list of these items has been deleted from the order.

Change in Allotment Symbol

The new allotment number U–9 is assigned for the purchase of controlled material for utility MRO instead of the former symbol MRO–U. This has become necessary to avoid confusion in accounting for orders received by metal mills and reported by them. The certification to be used on orders by producers has been changed accordingly, in paragraph (e). At the same time it has been made clear that a preference rating is not applicable to orders for controlled material.

In this connection it should be emphasized that, under paragraph (i) of U–1 and Priorities Regulation 13, a producer may sell controlled material from his inventory to any one who places with him an "authorized controlled materials order"—that is, an order placed with him without a preference rating, but to which has been applied an allotment symbol or number with a valid form of certification, like that of paragraph (e). In other words, a utility may accept an order for steel pipe, wire or any other form of controlled material on the basis of an allotment symbol or number placed on the order by a person authorized to do so. If this is done, no preference rating is required.

Purchase of Aluminum Simplified

Paragraph (d)(3) of the order has been stricken out in this amendment. The special procedure required to obtain deliveries of aluminum is no longer in effect. Aluminum may now be purchased under the terms of U–1 on the same basis as other forms of controlled material.

Deletion of Procedure of Former Paragraph (e)(2)

The procedure under former paragraphs (b)(2) and (e)(2) has been superseded by the development of Supplementary Orders U–1–d, U–1–f and of the requirement that all applications for construction be submitted on Form WPB–2774, except those eligible for submission on Form PD–545. These paragraphs have therefore been deleted in the present amendment.

Other Changes

The second sentence of paragraph (o), which refers to the relationship between U–1 and other War Production Board regulations and orders has been amended to make it clear that producers who are covered by U–1 are not affected by CMP Regulation 5, which is the blanket maintenance and repair order applicable to most industries.

Subparagraph (f)(5)(ii) which provides for the purchase of "short items" has been restated in a simplified manner.

Records of Materials Used Under Order U–1

The wording of paragraphs (a)(11), (f)(1), (f)(2) and (f)(3) has been simplified and clarified. In this connection the following statement is made to clear up questions which have been raised as to the inclusion or exclusion, in records of deliveries and withdrawals under U–1, of the value of materials used in capital additions.

Include in your records of deliveries and withdrawals, subject to the restrictions of paragraphs (f)(1) and (f)(3) of U–1, the dollar value of material used in all *minor capital additions* to your plant, whether th minor capital addition is permitte under the provisions of Utilities O der U–1 or supplementary orders the U–1 series, or by specific author zation by the War Production Boar (such as on Form WPB–2774).

A *minor capital addition* under U- is one in which the net dollar value o all materials used is less than $15(for underground construction or $5(for other construction.

Exclude from such records the valu of materials used in all *major capit additions.*

A *major capital addition* is one w which the net dollar value of all mate rials used exceeds the above dolla limits.

Net dollar value for determinin minor and major capital additions un der U–1 means *the cost of all materi to be installed on the job* LESS th cost of material to be salvaged fro the job and either returned to inven tory or scrapped, priced in accordanc with your regular accounting practic in making capital retirements.

Property replacements are classed a "repairs" under U–1 (paragraph (a (6)), rather than as capital additions if facilities or equipment which ar unfit or unsafe for service are re placed with facilities of *equal or les capacity*. The dollar limits of para graph (a)(7)(ii) are not applicable in such cases, and specific application are not necessary regardless of th cost of the replacement. Of course the quota provisions of paragraph (f) are applicable in all cases.

Very truly yours
(signed)
J. A. KRUG, *Director*
Office of War Utilities

TITLE 32—NATIONAL DEFENSE

Chapter IX—War Production Board

Subchapter C—Director, Office of War Utilities

Part 4500—Electric, Gas, Water and Steam Utilities—Materials

UTILITIES ORDER U-1 AS AMENDED SEPTEMBER 24, 1943

EDITOR'S NOTE: *Order U–1 as Amended April 17, 1943, was reproduced in full in the May* JOURNAL, p. *670. In the following pages only the revised paragraphs of the order as amended since that date are being printed. For the reader's convenience, the current and previous wordings of the amended paragraphs are being shown in parallel columns, the changes being shown in italic in each version.*

Current Order

(a) *Definitions*

(11) "Inventory" means all new or salvaged material in the producer's possession, unless physically incorporated in plant, without regard to its accounting classification, excluding, however, appliances, merchandising supplies and material in the producer's possession which is segregated for use in *"construction" as defined in paragraph (a) (12). After completion of "construction" any material remaining shall be included in "inventory."*

(14) "Short item" means any item of material which the producer *does not possess in sufficient quantity to meet his requirements for* maintenance, repair and operating supplies during the 90 days following its delivery date.

(b) *Preference ratings*

(1) *In the case of material to be used, or to replace material used,* for maintenance, repair and operating supplies (*other than operating supplies for use in extending lines to consumer premises*), a preference rating of AA–1 is hereby assigned to orders to be placed by producer for material *other than controlled material.*

Previous Order

(a) *Definitions*

(11) "Inventory" means all new or salvaged material in the producer's possession, unless physically incorporated in plant, without regard to its accounting classification, excluding, however, appliances, merchandising supplies and material in the producer's possession which is segregated for use in *additions and expansions specifically authorized—(a) under paragraph (e)(2) of this order, or (b) by an operative order in the P–19 series or (c) by an operative preference rating certificate issued by the War Production Board. After construction of such an addition or expansion is complete, however, any material remaining shall be included in "inventory," even though the rating therefor is still operative.*

(14) "Short item" means any item of material which the producer *estimates he will require for use in* maintenance, repair or as operating supplies during the 90-day period following its delivery date.

(b) *Preference ratings*

(1) For maintenance, repair and operating supplies, a preference rating of AA–1 is hereby assigned to orders to be placed by a producer for material (*including controlled material, Class A products, Class B products and other products or material*).

Current Order

(2) In the case of material to be used, or to replace material used, for extending to consumer premises authorized lines costing no more than the dollar limits established for operating supplies in paragraph (a)(7) of this order, a preference rating of AA–3 is hereby assigned to orders to be placed by a producer for material other than controlled material.

(c) *Restrictions on use of rating*

(3) To obtain any item *in violation of Priorities Regulation 3.*

(d) *Assignment of CMP allotment* number

(1) *The abbreviated CMP allotment number U–9 is hereby assigned (in place of the symbol MRO–U)* to orders to be placed by a producer for controlled material for use in maintenance, repair or as operating supplies.

(2) An order for controlled material for use in maintenance, repair or as operating supplies, bearing *the abbreviated CMP allotment number U–9* and the certification set forth in paragraph (e) hereof shall be deemed an authorized controlled material order. *This abbreviated CMP allotment number* shall constitute an "allotment number or symbol" for the purpose of CMP Regulation 3.

(3) [*Deleted*]

Previous Order

(2) For construction of transmission, switching and distribution facilities necessary to serve rated projects or to serve rated equipment, the lowest rating assigned to such project or to the delivery of such equipment, is hereby assigned, subject to the provisions of paragraph (e)(2), to orders to be placed by a producer for material (including controlled material, Class A products, Class B products and other products or material).

(c) *Restrictions on use of rating*

(3) To obtain any item *listed in Schedule E hereof.*

(d) *Assignment of CMP allotment symbol*

(1) *The CMP allotment symbol MRO–U is hereby assigned* to orders to be placed by a producer for controlled material, *except aluminum,* for use in maintenance, repair or as operating supplies.

(2) An order for controlled materials *except aluminum,* for use in maintenance, repair or as operating supplies, bearing *the CMP allotment symbol MRO–U* and the certification required in paragraph (e) hereof shall be deemed an authorized controlled material order *and shall have the same status as an order bearing an allotment number under all applicable CMP regulations unless otherwise expressly provided. Such allotment number or symbol* shall constitute an "allotment number or symbol" for the purposes of CMP Regulation 3.

(3) Aluminum required by a producer for use in construction approved under paragraph (e)(2) hereof or for use in maintenance, repair or as operating supplies may be obtained:

(i) On specific application to the War Production Board, Office of War Utilities, Washington, D.C., Ref: U–1, or

(ii) In amounts not exceeding 100 lb. per quarter as provided for in CMP Regulation 5, or

(iii) If delivery is to be from another producer, by placing an order rated in accordance with paragraphs (b) and (e) of this order.

Current Order

(e) *Certification*

The ratings assigned by paragraph (b) of this order and the abbreviated CMP allotment number U–9 may be applied by a producer only by use of a certification in substantially the following form:

Preference Rating ———, Abbreviated CMP Allotment Number U–9. The undersigned producer certifies, subject to the penalties of Section 35(A) of the United States Criminal Code, to the seller and to the War Production Board, that, to the best of his knowledge and belief, the undersigned is authorized under applicable War Production Board regulations or orders to place this delivery order, to receive, *for utility MRO under U–1, the material ordered,* and to use *the* preference ratings or allotment numbers which the undersigned has placed on this order.

The certifications set forth in Priorities Regulation 3 and CMP Regulations 1 and 5 may not be used.

Previous Order

(e) *Application and extension of ratings; application of CMP allotment symbol—*

(1) Certification

(i) The ratings assigned by paragraph (b)(1) of this order and the CMP allotment symbol MRO–U may be applied by a producer to deliveries of material (including controlled material, Class A products, Class B products and other products or material) for use in maintenance, repair and as operating supplies, only by use of a certification in substantially the following form (in lieu of the endorsement specified in Priorities Regulation 3 and CMP Regulation 5), except that no preference rating need be applied to an order to be placed with a controlled material producer.

Preference Rating AA–1, CMP Allotment Symbol MRO–U. The undersigned purchaser certifies, subject to the penalties of Section 35(A) of the United States Criminal Code, to the seller and to the War Production Board, that, to the best of his knowledge and belief, the undersigned is authorized under applicable War Production Board regulations or orders to place this delivery order, to receive *the item(s) ordered for the purpose for which ordered* and to use *any* preference rating or allotment number or symbol which the undersigned has placed on this order.

Such certification shall be signed manually or as provided in Priorities Regulation 7.

(ii) The ratings assigned by paragraph (b)(2) of this order may be applied by a producer to deliveries of material (including controlled material, Class A products, Class B products and other products or material), for use in construction to serve rated projects or equipment, by use of the certification provided in Priorities Regulation 3, as amended, except that no preference rating need be applied to an order to be placed with a controlled material producer and provided:

(a) That approval for such construction has been granted pursuant to paragraph (e)(2) hereof; and

(b) That the CMP allotment number assigned, upon approval of the construction pursuant to paragraph (e)(2), to deliveries of controlled material to be used in such construction by the producer is indicated on all rated orders.

Paragraphs (e)(2), (3) and (4), shown below, have been deleted.

(2) In addition to the requirements of paragraph (e)(1), a producer, in order to apply the preference ratings assigned by paragraph (b)(2), or to segregate material from inventory for the uses described in such paragraph, or to accept delivery of material for such uses, must, unless otherwise directed, communicate with the Office of War

Utilities, War Production Board, Washington, D.C., Ref: U–1, supplying in detail the following information or such other information as may from time to time be required:

(i) The producer's job number relating to the proposed construction

(ii) A description of the project or equipment to be served, including the location, an estimate of peak load and consumption, as well as other pertinent information

(iii) A description of the proposed utility construction, including a print of line construction showing size of conductor or pipe, capacity of transformers, pumps, compressors, tanks, holders and other equipment, the location of hydrants and important control valves, as well as other information relevant thereto

(iv) A statement of relationship to military needs, war production, public health or safety

(v) A copy of the customer's project or equipment preference rating order or certificate (Such copies of orders or certificates are not required when utilities' applications accompany the project application.)

(vi) A statement explaining whether service can be rendered in any other way, or by any other producer, with the use of smaller quantities of critical materials

(vii) An estimate of the total cost of the producer's project

(viii) A list of materials required for the construction, giving the estimated weight of each material with the estimated cost, classified as indicated in the instructions for revised Form PD–200 (Such list should indicate materials in inventory not to be replaced, materials to be purchased from excess stocks of other producers, materials to be obtained or replaced without priorities assistance and materials expected to be obtained or replaced with proirities assistance.

(ix) The dates when deliveries of controlled material as specified on Form CMP-4C are required to meet the construction schedule and the quantities of controlled material needed during each calendar quarter, excluding, however, controlled material to be obtained from other U–1 producers. The War Production Board will notify the producer whether and to what extent the application is approved and no producer shall apply such preference ratings, segregate material from inventory for the uses described in paragraph (b)(2) or accept delivery of material for such uses without such approval.

(3) The ratings assigned by this order may be extended by a supplier in the manner provided in Priorities Regulation No. 3 and CMP Regulation 3.

(4) An order for material, other than controlled material, bearing a rating assigned or extended in accordance with this paragraph (e) and a CMP allotment number or symbol shall have the same status as a rated order bearing a CMP allotment number under all applicable CMP regulations. Such number or symbol shall constitute an "allotment number or symbol" for the purposes of CMP Regulation 3.

Current Order

(f) *Restrictions on deliveries, inventory and withdrawals*

(1) *Scheduling deliveries:* No producer shall, in placing orders, schedule for delivery to him in any calendar quarterly period any material (whether or not rate pursuant to this order) to be used for maintenance, repair or as operating supplies, the aggregate dollar value of which shall exceed one-third of the aggregate dollar value of withdrawals of material of the same class from inventory for such uses during the last nine months of 1942.

Previous Order

(f) *Restrictions on deliveries, inventory and withdrawals*

(1) *Scheduling deliveries:* No producer shall, in placing orders, schedule for delivery to him in any calendar quarterly period any material (whether or not rated pursuant to this order) to be used for maintenance, repair, as operating supplies *or for any other purpose (except material to be segregated for use in additions and expansions specifically authorized under paragraph (e)(2) of this order, or by an operating order in the P–19 series, or by an operating preference rating certificate)*, the aggregate dollar value of which shall exceed one-third of the aggregate dollar value of withdrawals of material of the same class from inventory for such uses during the last nine months of 1942.

Current Order

(2) *Accepting deliveries; inventory restrictions:* No producer shall at any time accept any delivery of material (whether or not rated pursuant to this order) to be used for maintenance, repair or as operating supplies, if the producers inventory of material in the same class is, or will by virtue of such acceptance become, in excess of a practical working minimum. The value of such practical working minimum shall in no case exceed: [*Subparagraphs* (i), (ii), (iii) *and* (iv) *here remain unchanged.*]

(3) *Withdrawals:* No producer shall, during any calendar quarterly period, make withdrawals from inventory of material to be used for maintenance, repair or as operating supplies, the aggregate dollar value of which shall exceed one-third of the aggregate dollar value of withdrawals of material of the same class from inventory for such uses during the last nine months of 1942.

(4) *Exceptions:* Notwithstanding the provisions of paragraphs (f)(1), (2) and (3):

(i) A producer may, in any calendar quarterly period, increase scheduled deliveries and withdrawals of material in any of the classes named in paragraph (f)(2)(ii), over the limits prescribed in paragraphs (f)(1) and (f)(3), respectively, proportionately to the increase in system output in the twelve months' period preceding the current quarter over the system output in the calendar year *1940.*

Previous Order

(2) *Accepting deliveries; inventory restrictions:* No producer shall at any time accept any delivery of material (whether or not rated pursuant to this order) to be used for maintenance, repair, as operating supplies *or for any other purpose (except material to be segregated for use in additions and expansions specifically authorized under paragraph (e)(2) of this order, or by an operative order in the P–19 series, or by an operative preference rating certificate)*, if the producer's inventory of material in the same class is, or will by virtue of such acceptance become, in excess of a practical working minimum. The value of such practical working minimum inventory shall in no case exceed *the aggregate dollar value of inventory permitted, class by class, by paragraph (f)(2) of Preference Rating Order P–46 as amended October 10, 1942; provided that after March 31, 1943, the value of such inventory, class by class, shall not exceed:* [(i),(ii),(iii),(iv)].

(3) *Withdrawals:* No producer shall, during any calendar quarterly period, make withdrawals from inventory of material to be used for maintenance, repair, as operating supplies *or for any other purpose (except material to be sold or to be segregated for use in additions and expansions specifically authorized under paragraph (e)(2) of this order, or by an operative order in the P–19 series, or by an operative preference rating certificate)*, the aggregate dollar value of which shall exceed one-third of the aggregate dollar value of withdrawals of material of the same class from inventory for such uses during the last nine months of 1942.

(4) *Exceptions:* Notwithstanding the provisions of paragraphs (f)(1) and (3):

(i) A producer may, in any calendar quarterly period, increase scheduled deliveries and withdrawals of material in any of the classes named in paragraph (f)(2)(ii), over the limits prescribed in paragraphs (f)(1) and (f)(3), respectively, proportionately to the increase in system output in the twelve months' period preceding the current quarter over the system output in the calendar year *1942.*

Current Order

(vi) A producer, in order to provide for seasonal requirements of material for the maintenance, repair and operation of his system, may in any calendar quarterly period increase the dollar value of materials withdrawn for these purposes in *that* calendar quarter, provided that adjustments are made in withdrawals in other calendar quarters of the same calendar year to the extent that the total value of materials withdrawn during that calendar year do not exceed the amounts permissible to have been withdrawn during that calendar year under the terms of this order and of former Preference Rating Order P–46, as they may apply.

Previous Order

(vi) A producer, in order to provide for seasonal requirements of material for the maintenance, repair and operation of his system, may in any calendar quarterly period increase the dollar value of materials withdrawn for these purposes in *any* calendar quarter, provided that adjustments are made in withdrawals in other calendar quarters of the same calendar year to the extent that the total value of materials withdrawn during that calendar year do not exceed the amounts permissible to have been withdrawn during that calendar year under the terms of this order and of former Preference Rating Order P–46, as they may apply.

The following subparagraphs (vii), (viii) and (ix) have been added to paragraph (f)(4) "Exceptions" under the general heading "Restrictions on deliveries, inventories and withdrawals:

(f)(4)(*vii*) *A producer supplying water may in any calendar quarterly period schedule for delivery and withdraw from inventory material in Class 5 (as defined in Water Utilities Material Classification, Schedule A of this order), to be used for maintenance, repair and as operating supplies, having in the aggregate a dollar value not greater than 60 per cent of the aggregate dollar value of withdrawals of items of material in the same class during the corresponding calendar quarterly period of 1940, and no such producer shall be entitled to the quotas for scheduled deliveries and withdrawals established for Class 5 by paragraphs (f)(1) and (3).*

(f)(4)(*viii*) *In the case of a producer supplying water, the value of practical working minimum inventory in Class 5 (as defined in Water Utilities Material Classification, Schedule A of this order) shall in no case exceed 60 per cent of the aggregate dollar value of items of material of the same class in inventory on the most recent date during the calendar year 1940 on which the producer's inventory was taken.*

(f)(4)(*ix*) *No electric producer's practical working minimum inventory for meters shall exceed 50 meters plus 1¾ per cent of the meters installed in the producer's system as of the first day of the preceding quarter.*

Current Order

(f) *Restrictions on deliveries, inventory and withdrawals*

(5) *Short item deliveries:*

(i) (*c*) Reported to the War Production Board, when requested by the War Production Board, on *Form WPB–2641,* to the extent required by such form, or in such other manner as the War Production Board may prescribe, subject to the approval of the Bureau of the Budget in accordance with the Federal Reports Act of 1942, and

(ii) *Further provided,* That material transferred from excess to practical working minimum inventory on the records of a producer or used from excess inventory is recorded as a scheduled delivery under paragraph (f)(1).

(7) The provisions of paragraphs (f)(1), (f)(2) and (f)(3) shall not apply to fuel, water purification material (*excluding equipment*) and gas chemical material and supplies.

(o) *Applicability of regulations*

This order and all transactions affected thereby, except as herein otherwise provided, are subject to all applicable regulations of the War Production Board, as amended from time to time. *No producer is, however, subject to the restrictions of CMP Regulation 5, nor may any producer in any way use the preference ratings therein assigned.*

Previous Order

(f) *Restrictions on deliveries, inventory and withdrawals*

(5) *Short item deliveries:*

(i) (*c*) Reported to the War Production Board, when requested by the War Production Board, *on Form WPB–921 A, B, or C,* to the extent required by such form, or in such other manner as the War Production Board may prescribe, subject to the approval of the Bureau of the Budget in accordance with the Federal Reports Act of 1942, and

(ii) *Further provided* that material transferred from excess to practical working minimum inventory on the records of a producer or used from excess inventory is recorded as a scheduled delivery under paragraph (f)(1); *that is, that in any calendar quarterly period the aggregate dollar value of material in any class transferred on the producer's records from that portion of inventory which is separately accounted for as excess pursuant to this paragraph (f)(5) to practical working minimum inventory, or of material taken directly from such portion of inventory for use in maintenance, repair or as operating supplies, plus the aggregate dollar value of short item deliveries in such class, does not exceed one-third of the aggregate dollar value of withdrawals of material of the same class from inventory for such uses during the last nine months of 1942.*

(7) The provisions of paragraphs (f)(1), (f)(2) and (f)(3) shall not apply to fuel, water purification material and gas chemical material and supplies.

(o) *Applicability of regulations*

This order and all transactions affected thereby, except as herein otherwise provided, are subject to all applicable regulations of the War Production Board, as amended from time to time. *The restrictions of paragraph (f) of CMP Regulation 5, however, shall not apply to producers as defined in this order, nor shall the preference ratings assigned in CMP Regulation 5 supersede preference ratings assigned by this order.*

Current Order	Previous Order
Schedule A—Water Utilities Material Classification	*Schedule A—Water Utilities Material Classification*
2. Material (*excluding fuels*) for source of supply, *water treatment plants,* reservoirs, elevated and pressure tanks, pumping and booster stations, *including related pipe, valves, valve parts and fittings*	2. Material for source of supply, reservoirs, elevated and pressure tanks, pumping and booster stations (*excluding fuels*)
5. Transmission and distribution material and supplies (excluding meters), cast-iron, steel and wrought-iron pipe, copper and brass pipe and tubing, lead pipe, pipe fittings, valves and valve parts, hydrants, parts for meters and hydrants and other transmission and distribution materials and supplies, *except pipe, valves, valve parts and fittings included in Class 2 above*	5. Transmission and distribution material and supplies (excluding meters), cast-iron, steel and wrought-iron pipe, copper and brass pipe and tubing, lead pipe, pipe fittings, valves and valve parts, hydrants, parts for meters and hydrants, other transmission and distribution materials and supplies
Schedule C	*Schedule C*
A. 4. [*Deleted*]	A. 4. *Cement-asbestos pipe*
A. 14. [*Deleted*]	A. 14. *Steel tanks*
C. 1. Wire (all types), *including guy wire*	C. 1. Wire (all types)
C. 13. Lightning arrestors, *line types*	C. 13. Lightning arrestors, *20,000 volts and over*

Schedule E has been deleted; it is reproduced below for the reader's information.

No producer may apply the ratings assigned by this order to obtain delivery of any of the following items:

1. Fabricated containers (in knock-down or set-up forms, whether assembled or unassembled), required for packaging products to be shipped or delivered

2. Printed matter and stationery

3. Paper, paperboard and products manufactured therefrom; molded pulp products

4. Fuel or electric power

5. Office machinery or office equipment

6. Clothing, shoe or other wearing apparel, if made of leather or textiles, except that the following types may be included in operating supplies when specially designed and used to furnish protection against specific occupational hazards (other than weather):

a. Asbestos clothing

b. Safety clothing impregnated or coated for the purpose of making the same resistant against first, acids, other chemicals or abrasives

c. Safety industrial rubber gloves and hoods and linemen's rubber gloves and sleeves

d. Gauntlet type welders' leather gloves and mittens and electricians' leather protector or cover gloves

e. Other safety leather gloves or mittens but only if steel stitched or steel reinforced

f. Safety industrial leather clothing other than gloves or mittens

g. Metal mesh gloves, aprons and sleeves

h. Plastic and fiber safety helmets

7. Automotive replacement parts

8. Automotive maintenance equipment

9. Cellophane and similar transparent materials derived from cellulose having a gage of 0.003 in. and cellulose caps or bands of any gage.

Effect of Amendment of Order U-1-f

Order U–1–f, as amended on September 30, makes it permissible for a water utility to install up to 170 lb. of steel pipe to serve a domestic customer. The pressure limitations, under which steel could be installed, have been removed. If cement-lined steel pipe is used, the weight limitation of 170 lb. applies to the metal only and not to the combination of steel and cement.

Also, it should be noted that the commonly used combination of lead gooseneck and steel service line is recognized by the new schedules for domestic, commercial and industrial installations.

The basic conditions of Order U–1–f *must* in all cases be remembered. These conditions are that the extensions of service can be made (under this order) only to customers whose remodeling or construction jobs are so small as not to require an authorization from the WPB or the housing authority or any other federal agency. The order *permits* water utilities to extend water service to citizens whose private supply has broken down, but the new service *must not* duplicate an adequate service already installed or constitute a standby service.—*Harry E. Jordan, Secretary, A.W.W.A.*

SUPPLEMENTARY UTILITIES ORDER U-1-f AS AMENDED SEPTEMBER 30, 1943

EDITOR'S NOTE: *Supplementary Utilities Order U–1–f as issued on August 24, 1943, was reproduced in full in the September* JOURNAL, *p. 1245. In the following pages only the revised paragraphs of the order as amended September 24 are being printed. For the reader's convenience, the current and previous wordings of the amended paragraphs are being shown in parallel columns, the changes being shown in italic in each version.*

Current Order	Previous Order
(b) *Permission to build certain extensions*	*(b) Permission to build certain extensions*
(3) (ii) The consumer is engaged in the manufacture of a product or in the conduct of a business or activity listed in Schedules I or II of CMP Regulation 5, as amended, *or is a school, church or hospital.*	(3) (ii) The consumer is engaged in the manufacture of a product or in the conduct of a business or activity listed in Schedules I or II of CMP Regulation 5, as amended.
(5) The connection does not duplicate an adequate service already installed or constitute a standby service.	(5) The connection does not duplicate an adequate service already installed, or constitute a standby service, *or an enlargement of a service already installed.*

Current Order	Previous Order
Schedule A Localities in which extensions of *gas and electric services to domestic consumers* are permissible under the provisions of this Supplementary Utilities Order U–1–f.*	*Schedule A* Localities in which extensions of *utilities services* are permissible under the provisions of this Supplementary Utilities Order U–1–f

** A number of new localities have been added to the listed reproduced with the original order; since they have no relation to water utilities, however, they are not shown here.*

Schedule B—Utilities Construction Standards A. *Permitted Types of Conductor and Pipe* III. *Pipe:* a. *For mains 2 in. in diameter and larger* *(1) Cast-iron or non-metallic pipe.* *(2) Steel pipe in cases where installation conditions, high working pressures or danger of breakage or leakage make the use of cast iron impracticable or dangerous.* b. *For mains smaller than 2 in. in diameter and all service connections, any type of pipe except copper.* c. [*Deleted*]	*Schedule B—Utilities Construction Standards* A. *Permitted Types of Conductor and Pipe* III. *Pipe:* a. *Cast iron, for working pressures of 100 psi. or less.* b. *Steel, for working pressures of over 100 psi., or for working pressures of 100 psi. or less provided it is available in the producer's excess inventory or in the excess inventory of another producer.* c. *Non-metallic.*
B. *Permitted Quantities of Conductor and Pipe, Other Than Non-Metallic* I. *Domestic Consumers:* b. *For gas or central steam heating extensions:* (1) Up to 170 lb. of steel pipe or *1800 lb.* of cast-iron pipe, or (2) A combination involving not more than 170 lb. of steel pipe and not more than *1800 lb.* of cast-iron less twice the weight of any steel pipe used. c. *For water extensions* (1) Up to 170 lb. of steel pipe, or *1800 lb.* of cast-iron pipe, or 600 lb. of lead or lead-alloy pipe, or	B. *Permitted Quantities of Conductor and Pipe, Other Than Non-Metallic* I. *Domestic Consumers* b. *For gas or central steam heating extensions:* (1) Up to 170 lb. of steel pipe or *1200 lb.* of cast-iron pipe, or (2) A combination involving not more than 170 lb. of steel pipe and not more than *1200 lb.* of cast-iron pipe less twice the weight of any steel pipe used. c. *For water extensions:* (1) Up to 170 lb. of steel pipe, or *1200 lb.* of cast-iron pipe, or 600 lb. of lead or lead-alloy pipe, or

Current Order

(2) *One* of the following combinations:

(a) Not more than 170 lb. of steel pipe and not more than *1800 lb.* of cast-iron pipe less twice the weight of any steel pipe used, or

(b) Not more than 600 lb. of lead or lead-alloy pipe and not more than *1800 lb.* of cast-iron pipe less the weight of any lead or lead alloy pipe used, or

[New clause] *(c) Not more than 170 lb. of steel pipe and not more than 600 lb. of lead or lead-alloy pipe, less twice the weight of any steel pipe used.*

III. *Commercial consumers:*

b. *For gas or central steam heat extensions:*

(1) Up to 250 lb. of steel pipe, or *2000 lb.* of cast-iron pipe, or

(2) A combination of not more than 250 lb. of steel pipe and not more than *2000 lb.* of cast-iron pipe less twice the weight of any steel pipe used.

c. *For water extensions:*

(1) Up to 250 lb. of steel pipe, or *2000 lb.* of cast-iron pipe, or 1000 lb. of lead or lead-alloy pipe, or

(2) *One* of the following combinations:

(a) Not more than 250 lb. of steel pipe and not more than *2000 lb.* of cast-iron pipe less twice the weight of any steel pipe used, or

(b) Not more than 1000 lb. of lead or lead-alloy pipe, and *2000 lb.* of cast-iron pipe less the weight of any lead pipe used, or

[New clause] *(c) Not more than 250 lb. of steel pipe and not more than 1000 lb. of lead or lead-alloy pipe, less twice the weight of any steel pipe used.*

Previous Order

(2) *Either* of the following combinations:

(a) Not more than 170 lb. of steel pipe and not more than *1200 lb.* of cast-iron pipe less twice the weight of any steel pipe used, or

(b) Not more than 600 lb. of lead or lead-alloy pipe and not more than *1200 lb.* of cast-iron pipe less the weight of any lead or lead-alloy pipe used.

III. *Commercial consumers:*

b. *For gas or central steam heat extensions:*

(1) Up to 250 lb. of steel pipe, or *1800 lb.* of cast-iron pipe, or

(2) A combination of not more than 250 lb. of steel pipe and not more than *1800 lb.* of cast-iron pipe less twice the weight of any steel pipe used.

c. *For water extensions:*

(1) Up to 250 lb. of steel pipe, or *1800 lb.* of cast-iron pipe, or 1000 lb. of lead or lead-alloy pipe, or

(2) *Either* of the following combinations:

(a) Not more than 250 lb. of steel pipe, and not more than *1800 lb.* of cast-iron pipe less twice the weight of any steel pipe used, or

(b) Not more than 1000 lb. of lead or lead-alloy pipe, and *1800 lb.* of cast-iron pipe less the weight of any lead pipe used.

Copper Water Tubing

Direction 30 (as Amended September 21, 1943) to CMP Regulation 1

THE War Production Board intends, by the promulgation of Direction 30 to CMP Regulation 1 (reproduced on p. 1387), to suspend the sale of copper tubing (of the types used by water works) by the producer mills until the "frozen" stocks in the hands of the water utilities have been moved into the hands of users authorized to install copper under current conditions. The procedure of the Copper Recovery Corporation is to refer the firm authorized to use copper tubing to a water utility known to have the material on hand. The water utility can name the selling price, but the prospective user can also decline to buy at the price named. Water works men, therefore, must not attempt to boost prices above what the copper cost them or they may find themselves later facing an order to sell at junk prices. Some of the copper mills have been attempting to act as middlemen, but offering only the lowest jobber's price. Only a few of the largest water utilities ever bought copper at such a price. The authorized users of copper do not attempt to strip the price down so low, so that sales are being made at a fair level for both buyer and seller.

There is some question concerning the disposition that will be made of new copper tubing in lengths less than 10 ft. There is reason to believe that the Copper Recovery Corporation will permit utilities to place such short lengths in their working inventory. If short lengths exist, to any considerable extent, in the frozen copper inventory of a water utility, it would be advisable to request authority to hold such material in the working inventory for maintenance and operation.

One important unofficial policy can be recorded now. If a water utility has a stock of short copper tubing and fittings to go with it, permission can be obtained to use it for service line gooseneck. Such goosenecks (if ¾ in.) can be only 18 in. long, unless a very special and difficult situation must be met. Superintendents who wish to use copper tubing in this way should address a letter to: Mr. Irving C. Ralph, Chief, Conservation Branch, Copper Division, War Production Board, Washington, D.C.

State in the letter: (1) that it is estimated that _____ services will have to be installed during the period ending December 31, 1943; (2) that _____ services will have to be installed from January 1, 1944 to June 30, 1944; (3) that there is on hand enough copper service tubing to make 18-in. goosenecks for all such service lines; and (4) that authority is requested to make such use of the copper.

Do not ask to buy copper for such purposes. At present the answer will be—No! Do not add any argument

about the use of copper tubing to the simple request for authority to use a definitely stated amount. The writer has heard all of the arguments in favor of continued use of copper tubing by water works. He agrees profoundly with some of them and not at all with others; but he has had enough dealings with Washington to realize that wartime pressure causes men to make decisions that may not be equitable to all persons affected by them. If the inequity is great enough, the decision may be modified. If it is minor, it stands, although it may still be inequitable.

Now that the opportunity for negotiated sale of new long-length copper tubing exists, along with the alternate opportunity to obtain authority to use short lengths for goosenecks, the problem of the water utilities stocks of copper tubing seems to approach a reasonable solution.—*Harry E. Jordan.*

DIRECTION 30 (AS AMENDED SEPTEMBER 21, 1943) TO CMP REGULATION 1

The following direction is issued pursuant to CMP Regulation 1.

(a) The Copper Recovery Branch of the War Production Board has had reported to it considerable quantities of copper water tubing, types K, L and M, which are available for redistribution.

(b) Consequently, no order for copper water tubing, types K, L or M, shall hereafter be produced by any brass mill until the brass mill has received a specific authorization in writing from the War Production Board to fill the order. Such an authorization may be applied for by you from the Copper Recovery Branch, War Production Board, 200 Madison Avenue, New York, New York. The application should state the name of the person seeking to place, or who has placed, the order, and the quantity, type and size of copper water tubing required to fill it. Notwithstanding the above, until September 20, 1943, copper water tubing, types K, L, or M may be produced against orders accepted before the date on which this directive is issued.

Issued this 21st day of September 1943.

War Production Board
By J. Joseph Whelan
Recording Secretary

Emergency Alternate Provisions for Thicknesses of Steel Pipe

(Permissible Under WPB Limitation Order L-211, Schedule 13, Issued August 30, 1943)

THE following Emergency Alternate Wall Thickness Provisions to A.W.W.A. 7A.4–1941–TR—Tentative Revision of Standard Specifications for Steel Water Pipe of Sizes up to but Not Including 30 Inches were not included with other emergency alternate provisions previously published in the JOURNAL (35: 1238 (1943)).

Emergency Alternate Provisions to A.W.W.A. 7A.3–1940 and 7A.4–1941–TR will be made available with reprints of the specifications themselves, permitting their limited use under wartime conditions.

Sec. (EA) A4–3.1—Mill Pipe

Nominal Size	Outside Diam.	Wall Thickness (Decimal)	Weight Per Linear Foot	Working Pressure Safety Factor of 4.0		Approximate Ultimate Bursting Pressure		Test Pressure		
				40,000-psi. Fiber Stress	50,000-psi. Fiber Stress	40,000-psi. Fiber Stress	50,000-psi. Fiber Stress	Butt-Weld Plain or Threaded Ends	Lap-Weld, Grade A Seamless or Electric Welded	
									Plain Ends	Threaded Ends
in.	*in.*	*in.*	*lb.*	*psi.*	*psi.*	*psi.*	*psi.*	*psi.*	*psi.*	*psi.*
3	3.500	0.125	4.51	710	890	2860	3570	800	1300	
		0.216	7.58	1230	1540	4940	6170	800	2200	1000
3½	4.000	0.125	5.17		780		3120		1100	
		0.226	9.11		1410		5650		2000	1200
4	4.500	0.125	5.84		690		2780		1000	
		0.237	10.79		1320		5270		1900	1200
5	5.563	0.156	9.02		700		2800		1000	
		0.258	14.62		1160		4640		1700	1200
6	6.625	0.188	12.89		710		2840		1000	
		0.280	18.97		1060		4220		1500	1200
8	8.625	0.188	16.90		550		2180		800	
		0.250	22.36		730		2900		1000	
		0.322	28.55		930		3730		1300	1200

NOTE: The thicknesses for sizes ⅛-in. through 2½-in. are not affected by L-211.

Sec. (EA) A4–3.1—Mill Pipe—(Continued)

Nominal Size	Outside Diam.	Wall Thickness (Decimal)	Weight Per Linear Foot	Working Pressure Safety Factor of 4.0		Approximate Ultimate Bursting Pressure		Test Pressure		
				40,000-psi. Fiber Stress	50,000-psi. Fiber Stress	40,000-psi. Fiber Stress	50,000-psi. Fiber Stress	Butt-Weld Plain or Threaded Ends	Lap-Weld, Grade A Seamless or Electric Welded	
									Plain Ends	Threaded Ends
in.	*in.*	*in.*	*lb.*	*psi.*	*psi.*	*psi.*	*psi.*	*psi.*	*psi.*	*psi.*
10	10.750	0.188	21.15		440		1750		650	
		0.250	28.04		580		2330		850	
		0.365	40.48		850		3400		1200	1000
12	12.750	0.188	25.15		370		1480		500	
		0.219	29.28		430		1720		600	
		0.250	33.38		490		1960		700	
		0.375	49.56		740		2940		1100	1000
14	14.000	0.188	27.65		340		1340		450	
		0.250	36.71		450		1780		650	
		0.375	54.57		670		2680		950	950
16	16.000	0.188	31.66		290		1180		400	
		0.250	42.05		390		1560		550	
		0.375	62.58		590		2340		850	850
18	18.000	0.188	35.67		260		1040		350	
		0.250	47.39		350		1390		500	
		0.375	70.59		520		2080		750	
20	20.000	0.188	39.67		240		940		350	
		0.250	52.73		310		1250		450	
		0.375	78.60		470		1880		700	
22	22.000	0.188	43.68		210		860		300	
		0.250	58.07		280		1140		400	
		0.375	86.61		430		1700		600	
24	24.000	0.188	47.68		200		780		300	
		0.250	63.41		260		1040		350	
		0.375	94.62		390		1560		550	
26	26.000	0.188	51.69		180		720		250	
		0.250	68.75		240		960		350	
		0.375	102.62		360		1440		500	
28	28.000	0.188	55.69		170		670		250	
		0.250	74.09		220		890		300	
		0.375	110.63		340		1340		450	

NOTES:

1. Thicknesses of pipe given in these specifications are for the purpose of conserving steel, but if other thicknesses of pipe are produced for other purposes, or if such are in stock, which will conform to this specification, they may be used for water service.

2. Pipe thicknesses should be selected, not only with respect to the stresses to which the pipe will be subjected, but also with respect to the degree of corrosiveness of the soil and of the water to be carried, with due regard to the probable required life of the pipe. In cases where the water or ground, or both, have been known to be corrosive, due consideration should be given to the protection of steel water pipe, particularly that with thin walls. It is recommended that if coatings are used they comply with A.W.W.A. 7A.6–1940— Standard Specifications for Coal-Tar Enamel Protective Coatings for Steel Water Pipe of Sizes up to but Not Including 30 Inches in Diameter.

Engineers who specify or contemplate specifying steel pipe to be produced according to these emergency alternate specifications should consider carefully the physical characteristics, allowable wall thicknesses and probable life of steel pipe which can be produced in conformance with them. If steel pipe of such physical characteristics and wall thicknesses is not judged to be applicable to the service conditions under which it is expected to be used, some other type of water pipe should be specified.

Sec. (EA) A4–3.2—Fabricated Pipe

Outside Diam.	Wall Thickness		Weight Per Linear Foot	Working Pressure Safety Factor of 4.0 50,000-psi. Fiber Stress	Approx. Ultimate Bursting Pressure 50,000-psi. Fiber Stress	Test Pressure
	Mfr.'s Std. Gage No.	Decimal				
in.		*in.*	*lb.*	*psi.*	*psi.*	*psi.*
4	12	0.105	4.46	660	2620	1000
	10	0.135	5.69	840	3380	1200
6	12	0.105	6.75	440	1750	600
	10	0.135	8.64	560	2250	800
8	12	0.105	9.04	330	1310	450
	10	0.135	11.58	420	1690	600
	7	0.179	15.36	560	2240	800
10	10	0.135	14.53	340	1350	450
	7	0.179	19.28	450	1790	650
		0.188	19.64	470	1880	700
12	10	0.135	17.47	280	1120	400
	7	0.179	23.21	370	1490	550
		0.188	23.65	390	1570	550
14	10	0.135	20.42	240	960	350
	7	0.179	27.14	320	1280	450
		0.188	27.65	340	1340	450
16	10	0.135	23.36	210	840	300
	7	0.179	31.06	280	1120	400
		0.188	31.66	290	1180	400
18	10	0.135	26.31	190	750	250
	7	0.179	34.99	250	990	350
		0.188	35.67	260	1040	350
20	10	0.135	29.25	170	680	250
	7	0.179	38.92	220	900	300
		0.188	39.67	240	940	350
22	7	0.179	42.84	200	820	300
		0.188	43.68	210	860	300
	3	0.239	56.97	270	1090	400
24	7	0.179	46.77	190	740	250
		0.188	47.68	200	780	300
	3	0.239	62.21	250	1000	350
		0.250	63.41	260	1040	350
26	7	0.179	50.70	170	690	250
		0.188	51.69	180	720	250
	3	0.239	67.44	230	920	300
		0.250	68.75	240	960	350
28	7	0.179	54.62	160	640	250
		0.188	55.69	170	670	250
	3	0.239	72.68	210	860	300
		0.250	74.09	220	890	300

NOTES:

1. Thicknesses of pipe given in these specifications are for the purpose of conserving steel, but if other thicknesses of pipe are produced for other purposes, or if such are in stock, which will conform to this specification they may be used for water service.

2. Pipe thicknesses should be selected, not only with respect to the stresses to which the pipe will be subjected but also with respect to the degree of corrosiveness of the soil and of the water to be carried, with due regard to the probable required life of the pipe. In specifying steel pipe under these emergency alternate specifications, it is recommended that it be coated and lined in accordance with A.W.W.A. 7A.6–1940—Standard Specifications for Coal-Tar Enamel Protective Coatings for Steel Water Pipe of Sizes up to but Not Including 30 Inches in Diameter.

Engineers who specify or contemplate specifying steel pipe to be produced according to these emergency alternate specifications should consider carefully the physical characteristics, allowable wall thicknesses and probable life of steel pipe which can be produced in conformance with them. If steel pipe of such physical characteristics and wall thicknesses is not judged to be applicable to the service conditions under which it is expected to be used, some other type of water pipe should be specified.

Current Activities of the Steel Water Pipe Committee

BETWEEN June 1942, and June 1943, Committee 7A submitted a revision of Specification 7A–4–1941 TR. which was approved at the January 1943, meeting by the Board of Directors and published in the April 1943, JOURNAL.

On December 11, 1942, the Industrial Engineering Company, Wilmington, Calif., submitted to all members of Committee 7A, General Specifications covering "Somastic Pipe Coating" for consideration as an exterior protection *only* for steel water pipe, requesting its adoption as one of the approved Standard Pipe Coating Specifications of the A.W.W.A. This in turn was referred by the Chairman to the Subcommittee on Coating of the Steel Water Pipe Manufacturers Technical Advisory Committee for report to Committee 7A.

The general use made of the standard specifications compiled by Committee 7A is gratifying. With the co-operation of the Steel Water Pipe Manufacturers Technical Advisory Committee, these specifications will be modified from time to time and others compiled in line with the best recognized practice.

Committee 7A, at Chicago, decided to compile a Manual for Design and Installation of Steel Water Pipe Lines. Following is the outline of the Manual as presently planned:

Chapter I

Design

- Internal Pressure
- External Loads
- Water Hammer
- Expansion Joints
- Anchorage
- Ring Girder Pipe Construction
- Saddles
- Fittings and Special Appurtenances *
  - Design
  - Standardization of Shapes
- Flanges

* Air and vacuum valves and the proper spacing of regular gate valves.

Chapter II

Material Specifications

List of Standard A.W.W.A. Material Specifications (Tanks, Valves, Meters, Protective Coatings, etc.).

Chapter III

Steel Pipe Protection

Appurtenant Information and Recommendations with regard to:

- Coal-Tar Enamel Protection
- Cement Linings and Coatings
- Cathodic Protection
- Other Types

Chapter IV

Installation of Steel Pipe

- Transportation and Handling
- Excavation
- Joints
  - Field Welded *
  - Mechanical Couplings
  - Bell and Spigot
  - Other Tubes
- Laying
- Anchorages
- Miscellaneous †
- Backfilling
- Leakage Test

* A.W.W.A., American Welding Society Specification Activity.

† Includes Installation of Valves, Manholes and Appurtenant Fittings.

Coal for Water Works

COAL supply is another one of the problems that the war has put on an uncertain basis. The danger of a coal shortage this winter is the prime reason for the current conservation program. Production of coal per miner per day appears to be less than it was before this summer's strike. This adds to the uncertainty affecting all coal users. If the problem of coal supply was ever serious, it is far more serious now.

In November 1942, at the request of the Water Branch of the Office of War Utilities, the A.W.W.A. sent to 853 cities and water districts, serving populations greater than 10,000, a request for certain information concerning the use of coal in water supply plants. This was followed by further requests for the same information in December 1942 and again early in 1943. Of the 853 plants contacted, 692 eventually furnished information, which may be summarized briefly, as follows:

Of the 692 plants reporting, 494 advised that they used no coal for power, 82 that they used coal in combination with power sources and 116 that they depended exclusively upon coal for pumping. The extent of electrification of water works pumping stations is indicated by the fact that 346, exactly half, reported that they depended exclusively upon electric power to operate their pumping units. Oil and/or gas were used by 34 plants and 60 operated gravity systems. In the remaining 24 plants, a combination of electricity, oil and/or gas was used. The storage of coal reported as of November 1942 ranged from 75 to 105 days' (2.5 to 3.5 months) supply.

Under the terms of the Solid Fuels Administration Order of September 3, the coal producers in District 8 cannot ship more than 75 per cent of the current monthly requirements to a civilian agency (such as water works) if it has in storage more than a 30-day supply. Electric power plants are allowed a 60-day supply before the 75-per cent monthly allotment governs. Regulation 2 is, broadly, a reduction of the distribution of anthracite to 90 per cent of that in the base period year which ended March 31, 1943.

The following recent directives of the Solid Fuels Administration (cited by page number in *Federal Register*) affect the distribution of coal:

Reg. 3	8/20/43	p. 1165
Reg. 4	8/21/43	p. 1165
Order 3	8/23/43	p. 1171
Order 4	8/27/43	p. 1189
Reg. 2 (rev.)	8/27/43	p. 1189
Reg. 5	9/2/43	p. 1216
Reg. 4 (Amendment 1)	9/3/43	p. 1228

—HARRY E. JORDAN
Secretary, A.W.W.A.

The Manpower Situation

By Harry E. Jordan

THE shortage of manpower in the United States, as of early autumn 1943, is at a very critical stage. The total of civilian workers and military forces by midyear, 1944, is expected to reach sixty-five and a half million persons. The adjustment among civilian workers, required for a labor force a million and a quarter greater in 1944 than in 1943, is expected to be made up by further reduction of the unemployed group; by reducing substantially (more than 1½ millions) the number of people in trades and services; by bringing at least half a million more women into industry; and by the normal growth of population which, in the gross, amounts to 700,000 persons a year.

In the field of transportation, fuel and all utilities, it is estimated that 500,000 more persons must be employed by the middle of 1944 than were thus employed in 1943.

Labor Allocation System

The West Coast manpower situation is such that a virtual system of priorities or allocation of labor is emerging. Some observers feel that this is inevitable, for the duration, over the entire nation, but that we shall more or less back into it, rather than enter into such a program forthrightly.

There are some interesting facts about public water supply that merit thought in this connection. Water works, generally, have employed one person per 1000 persons served. Cities with a population of over a quarter of a million generally employ one person per 1500 served. The investment in water works property in a large, well managed and well built water works system will amount to $75,000 per employee. Small cities with simple systems will have invested less. Large western cities in areas where water is scarce and where it must be brought a long distance must invest much more per employee or per person served. A study of the materials used in water works construction made a year ago disclosed that for every person served by water works, about 600 lb. of metal was installed per person served—or 600,000 lb. of metal per employee of the water works in the average medium sized city.

These figures actually have a material bearing on the manpower needs of water works—and they simply come down to this: The normal manpower demand by water works is small, either in terms of persons served or per dollar invested per employee. An industry that normally uses much material and little manpower to serve its field, cannot continue its service adequately with any material reduction of the manpower available to it.

A contribution by Harry E. Jordan, Secy., A.W.W.A.

Reports From the Field

The adjustments in water works practices, that have so far come about in water works since the manpower problem began to be acute, have been recorded with the A.W.W.A. in a series of very illuminating letters recently filed. Members who have been helpful in this way are listed at the close of this article.

H. B. Miles of Utica, N.Y., epitomized his operations in the following succinct form:

	Per cent
Increased production	10
Decreased construction	99
Decreased maintenance	27
Decreased operating personnel	14
Decreased automobile mileage	21
Decreased automobile gas consumption	28

Broadly, three things have been done to save manpower:

1. Construction is at a practical standstill.
2. Major or routine maintenance is being deferred.
3. Meter reading and customer services are being reduced.

It should be noted, however, that while manpower has been saved by these policies, factors other than a purposeful plan to save manpower brought them about. Major construction work was stopped because authority to carry it on could be obtained only where war related needs made it imperative. Men formerly used on construction work were moved into plant operation to take the place of those who had left for military service or for other civilian employment. Likewise many maintenance routines, such as valve testing and replacement, meter testing and replacement, painting and related building maintenance, hydrant replacement, main flushing, etc., have been drastically reduced or even suspended for the duration. Water works managers have been forced to suspend these routines, *which are a basic part of good water works management,* not because they planned to save manpower, but because they had to use available remaining manpower on other duties that had to go on, like the postman, through rain and sleet and snow.

Meter Reading

Finally, meter reading, formerly done in many cities on a monthly basis is now being done on a quarterly basis in many cities. Customer reading of meters is being encouraged and works much better than might have been anticipated. The tenant or property owner is mailed postcards for him to mark and return on specific dates. With certain minor exceptions, attempts at chiseling are infrequent. This change of operating policy has probably been the most definitely planned of all the manpower saving devices of water works. But it likewise was not planned in the abstract, in order to save labor, but planned because management found itself driven to some method of using the remaining personnel in operation of the plant. Utility office work is now dominantly done by women. Laboratory work and some filter operation is done by women.

As yet there is no record of changes in operation that have reduced the total number of workers in pumping stations and in filtration plants. Here the normally low manpower use affords little opportunity to cut the number of workers. There is little "featherbedding" in water works, so that

affords no opportunity for saving. Some plants are reducing water pressure in the late night hours, but that saves coal or current, not manpower. Over the entire water works field, the reduction in manpower appears to amount to not less than 10 per cent nor more than 15 per cent of the total employed in 1940.

With the employment situation what it is today, water works management finds itself faced with the task of keeping on the job those long term loyal employees who remain, and adjusting the duties assigned to them to the end that the essential operations of the plant will be efficient and uninterrupted.

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Use Water Usefully

WHEN the Government asked water works utilities to co-operate with other public service groups in a campaign to stop waste as a war measure, the A.W.W.A., began preparing promotional aids for use by water works in publicizing *Use Water Usefully*. It now is possible for water works to order from the A.W.W.A., advertising material at moderate prices.

Two of the six newspaper advertisements available in three sizes, are shown on the following pages. Below is the price list covering all advertising material:

	Size	*Quantity*	*Price*
Newspaper Advertisements (without imprint):			
Use Water Usefully This Is a Leaky Faucet Pouring Water on a Duck's Back Pouring Water Into a Rat Hole Pouring Water Through a Sieve Joe and I Worked Together	2-column mat ..... 3-column mat ..... 4-column mat	1..... 1..... 1.....	$ .50 .75 1.00
Reprints of Newspaper Advertisements (Imprinted with utility name and address; on white coated paper)	4-column 4-column	500..... 1,000.....	20.00 30.00
Leaflet—Water Is Public Necessity (Imprinted with utility name and address; on blue paper)	8½ × 11-in.	500..... 1,000..... 5,000..... 10,000.....	25.00 40.00 100.00 150.00
Sticker (gummed, without imprint; red on white paper)	3¼ × 10½-in.	1,000..... 2,500..... 5,000..... 10,000.....	30.00 40.00 60.00 100.00
Enclosure—Your Uncle Sam Wants Water Waste Stopped (imprinted with utility name and address)	8½ × 11-in.	1,000..... 5,000..... 10,000.....	20.00 60.00 100.00
Posters (without imprint, printed in 3 colors):			
1. If You Can't Get a Plumber 2. Planes, Guns, Tanks 3. Protect Production 4. Don't Be a Drip	7¾ × 11-in. Equal quantities of the 4 posters (250 of each) ..... Your choice of any one of the posters...	1,000..... 1,000.....	15.00 20.00

Mailing or shipping charged additional.

Order should be forwarded on your regular purchase orders, to American Water Works Association, 500 Fifth Avenue, New York 18, N.Y.